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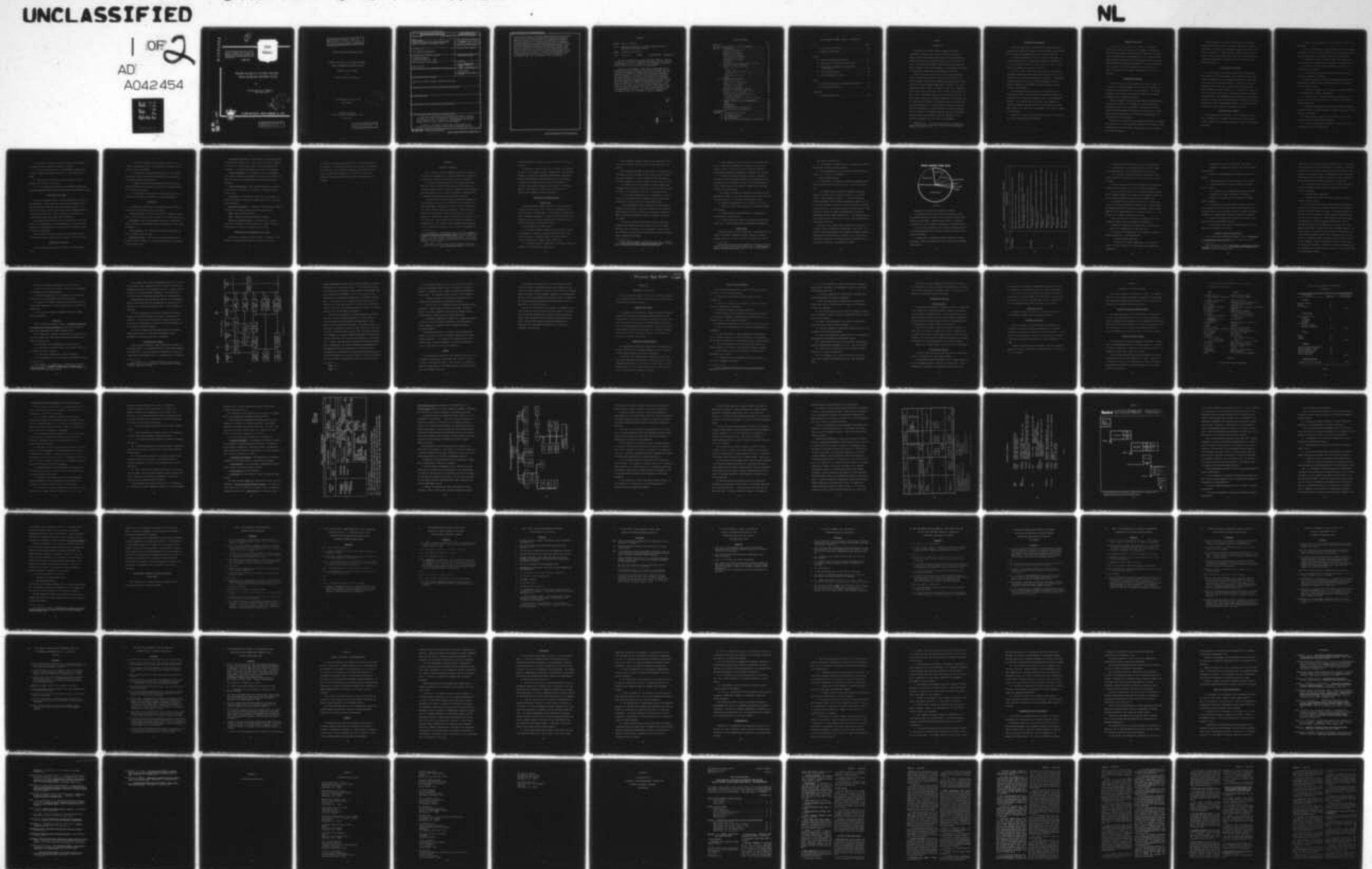

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8 JUNE 1977

STUDY PROJECT

IMPROVING RELIABILITY OF AVIONICS EQUIPMENT THROUGH ENGINEERING DEVELOPMENT TESTING

BY

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USAWC MILITARY STUDIES PROGRAM PAPER

IMPROVING RELIABILITY OF AVIONICS EQUIPMENT THROUGH ENGINEERING DEVELOPMENT TESTING

INDIVIDUAL STUDY PROJECT

by

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The basic consideration in this exploratory study is: Can the reliability of avionics be enhanced by improving (1) the reliability test methodology, (2) our reliability test philosophy, and (3) performing tests in a more realistic test environment.

Mr Wallis J. Willoughby, Deputy Chief of Naval Materiel for Reliability and Maintainability, Naval Materiel Command, made the

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statement that testing is probably responsible more than any other single factor for the poor reliability of military procurements. This study suggests a strategy for the acquisition of avionics equipment with the goal of improving reliability by finding and correcting engineering design deficiencies as early as possible in the Acquisition Process (Engineering Development Testing). Information on reliability problems as associated with avionic reliability was derived from a literature search (primarily previous studies in the field) and personal interviews with experts in the field of avionics reliability. The paper concludes with a series of recommendations that may result in improved reliability and contribute to the cost of ownership of avionics equipment.

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CHAPTER I

INTRODUCTION

Acquisition of reliable avionics equipment with lower operational and support cost is crucial if we are to meet the growing needs of increasingly sophisticated avionics systems and subsystems required to accomplish present day and future air missions. The existing Department of Defense managerial approaches are not adequate to meet this challenge. A few examples are included in this report to demonstrate the foundation of this view.

Today each of the services is faced with less-than-desired combat effectiveness levels and rising life cycle cost for new weapons systems. This situation exists because reliability requirements have not been adequately specified or enforced. The lack of adequately reliable avionics contributes to the cost of ownership in many ways; cost of down time, cost of failure, pilot safety, the direct cost of maintenance spares, labor, training, personnel, etc. As an example, the Navy is currently spending $0.5 billion per year in a peace-time environment for spare parts alone, to repair some two million failures.[1] It is the opinion of this writer that the reliability achieved for a military system is directly dependent upon the reliability requirements imposed, and upon the management emphasis placed on reliability by both the government and the contractor throughout the life cycle of the equipment.

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[1]Admiral Isaac C. Kidd made this statement in describing the supply and depot-level maintenance pipeline (Defense Management Journal, April 1976, p. 13).

STATEMENT OF THE PROBLEM

The problem addressed is the Engineering Development (Test-Analyze-Find and Correct) testing of avionics systems and subsystems and the impact of implementing the C version of MIL-STD 781.

The increased complexity of today's avionics subsystems, the associated maintenance and operational support cost coupled with the less-than-desired level of reliability is the subject of wide interest throughout the Department of Defense.

One of the areas that has nationwide interest is the lack of correlation between the demonstrated reliability test data in the laboratory and the observed reliability test results. The problems associated with the subject engineering development testing of avionics equipment is considered a significant problem by both government and industry.

The growing awareness and concern by the Congress of the relationship between life cycle cost and unreliable equipment are reflected in the criticism by Congress of our current acquisition policies. This condition plus the limited funds available to acquire new weapons requires industry and the government to work more closely and to draw upon the knowledge of each other to resolve this situation.

With this in mind, the many factors which influence reliability of avionic subsystems will be discussed.

PURPOSE OF THE STUDY

The purpose of this study is to explore the reliability problems associated with engineering development (Test-Analyze-Find and Correct Phase) testing of avionics subsystems and equipment; to examine some of the implications of the C version of MIL Standard 781; to identify some of the significant issues and problems associated with achieving reliability for avionic subsystems; and to attempt to provide recommendations that may result in improved reliability and contribute to reduction in the cost of ownership.

BACKGROUND INFORMATION

For years we have observed significant variances between the reliability of avionics equipment in the field under operational conditions and that demonstrated in the laboratory. The specific reasons for such variance have been the subject of many studies sponsored by both the DOD and industry.

Despite management efforts and technological improvements made during the past decade, the reliability of avionics systems and subsystems is still lower than desired. Because low reliability ultimately degrades military readiness and increases cost of ownership, all of us associated with the military can appreciate the ramifications of this situation.

Efforts are now under way in the Department of Defense to improve this condition. In the future greater emphasis will be placed on both reliability design and realistic testing during the early phases of the acquisition process.

DOD and industry are jointly working toward increasing the realism of laboratory testing. The basic concept is to combine performance, reliability and environmental testing (combined stress) insofar as practical. Colonel Ben Sweet, ODDR&E, identified this subject as one of the missing links in the present MIL-SPEC-MIL-STD arrangement between DOD and industry. This new approach is the basis of this study.

SIGNIFICANCE OF THE STUDY

The significance of the study is derived from its potential contributions to the understanding of the problems associated with avionics reliability and the possible development of a system that would permit the continuous assessment of reliability during the equipment's entire life cycle. This would result in increased combat readiness and lower logistic cost. The results of this study will be forwarded to DOD, Office of the Director, Defense Research and Engineering. The recommendations and findings of this study are timely as an input to the new DOD Directive on Reliability and Maintainability of System and Equipment (5000.X). This draft directive is currently being circulated for comments and inputs.

QUESTIONS TO BE ANSWERED

For the purposes of this study, a set of objectives, in the form of questions to be answered, was developed. These questions provided guidelines for the literature research and for the personal interviews:

1. What is your perception of the current DOD reliability test philosophy?

2. Do you think DOD has a common definition of what constitutes a reliable system, i.e., field reliability to the logistician may not mean the same thing to the designer or contract administrator?

3. Does the need exist for DOD to provide more guidance or a policy directive to establish a more realistic reliability program?

4. What factors, other than environmental, influence poor reliability in the field?

5. In your opinion, do we adequately monitor those factors that effect equipment reliability?

6. Can the reliability of avionic subsystems be improved by improving the reliability test methodology during the early phase of the acquisition cycle?

7. Do we do an adequate job, contractually, defining reliability requirements (for avionic subsystems)?

8. Does the current logistic reporting system provide the kind of data from the field necessary to improve the reliability of avionic subsystems?

9. Does the DOD Representative provide the equipment designer and the reliability engineers adequate information during the initial phase of the program?

10. What is your perception of our ability to provide the contractors with realistic mission profiles?

11. How much reliability consideration should be given to the conceptual and initial design phase?

12. How much consideration should be given to the reliability requirements during engineering development testing?

13. What should be the role of the Government representatives during the engineering development test, i.e., test find and fix phase?

14. What are your perceptions of the cost impact of implementing the C version of MIL-STD 781?

15. If we implement the C version of MIL-STD 781, will we have closer correlations between lab test results and field reliability data?

LIMITATIONS OF THE STUDY

This is an exploratory study of avionics subsystems reliability. The development of this study was restricted by the scheduled time as defined by the US Army War College for research projects. All major data collection and interview sessions were completed between 17 March and 28 April 1977. These activities were conducted on a noninterference basis with other school requirements.

The agencies and personnel selected to participate in the study were not all encompassing. Key representatives of various agencies whose primary responsibilities are concerned with reliability issues were asked to participate.

The results of the study were based on the analysis of data obtained from personal interviews and a review of related literature.

ASSUMPTIONS OF THE STUDY

The following assumptions were made prior to initiating this study.

1. The current emphasis by DOD to improve reliability of avionics equipment may lead to new managerial strategies that will reduce the cost of ownership.

2. Reassessment of current methodologies used in conducting reliability testing and establishing reliability requirements may reduce operational and support cost.

3. Feedback from the current maintenance reporting systems provides inadequate and untimely data required to improve reliability of avionics equipment.

4. Timely input from the field concerning accurate mission profiles could enhance the reliability of avionics equipment.

DEFINITIONS

For purposes of this study, the following terms are defined to clarify specific meanings as used in this study:

Corrective Action: The process, procedure, or material changes made to correct the true cause of a failure, to include documentation.

Environment: All the environmental stresses and combinations thereof, effecting systems during operation performance, and/or field environments.

Failure Analysis: The identification of the failure mode, the failure mechanism, and the cause.

Mean-time-to-repair: The total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time.

Maintenance Reliability: The probability or probable duration of specified performance, by a given system, subsystem or equipment and all of its component parts, under specified conditions and procedures. (Readiness and ownership cost factor; see Failure.)

Mission Reliability: The probability that an operationally ready system, subsystem or equipment will initiate and complete one specified mission upon command, under specified conditions and procedures.

Predicted Reliability: That reliability which is expected at some future date, postulated on analysis of the design and the failure rates.

Reliability: The probability that a piece of equipment will perform its intended function for a specified period of time under stated conditions.

Reliability Assessment: An estimate of the achieved reliability obtained by calculations using data gathered during tests.

MTBF: Mean Time Before Failure.

CERT: Combined Environment Reliability Testing.

Failure vs. Relevant Failure: No attempt will be made to clarify what constitutes relevant failure vs. failure. Existing definitions will suffice for purposes of this study.

ORGANIZATION OF THE REMAINDER OF THE STUDY

This study is presented in five chapters. In Chapter I, the problem is defined and the purpose of the study is outlined.

In Chapter II, a review of previous studies and related literature is presented. The methods and procedures of thestudy are presented in Chapter III. The analysis of the data and the findings of the study are presented in Chapter IV. In Chapter V, the study is summarized and significant conclusions and recommendations are reported.

CHAPTER II

REVIEW OF LITERATURE

Recent studies of avionics equipment reliability support the conclusion that equipment is not being designed for, or tested in, an environment similar to that in which it will be employed.[1]

As a result, operational stresses are causing failure modes that were neither considered during design nor discovered and eliminated during testing. Of all the challenges faced by avionics equipment designers, none exceeds in magnitude or importance that of providing operational forces with reliable equipment.[2]

A review of the related literature indicated the problem considered (within the confines of this study) had not previously been investigated. However, many studies have been conducted on the overall subject of avionics reliability. These studies considered many factors which effect poor reliability of avionics equipment. These studies, ranging in duration of development from 19 to 30 months, were conclusive and contained many excellent recommendations. The findings suggested there are many inconsistencies in policies, approaches, etc., and that there was general

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[1]A. Dantowitz, C. Hirstchberger, and D. Provideo, Analysis of Aeronautical Equipment Environmental Failure, Air Force Flight Dynamics Laboratory (Wright Patterson AFB: Air Force Systems Command), p. 71; also, B. Swett, "Avionics Reliability Study," Final Report of the Joint Logistics Command Electronic System Reliability Workshop, 1 October 1975.

[2]LTG Robert T. Marsh, USAF, "Avionics Equipment Reliability, An Elusive Objective," Defense Management Journal, April 1976.

confusion concerning the cause of poor reliability of avionics equipment.

The DOD policy documents were also included in the review of literature. The specific documents reviewed were: MIL-STD 785--Reliability Program Plan; MIL-STD 756--Reliability Predictions; MIL-STD 781C--Reliability Design Qualification and Production Acceptance Tests: Exponential Distribution; MIL-HDBK 217; AR 702-3--Army Materiel Reliability, Availability and Maintainability; and DOD Directive 5000.X (draft)--Reliability and Maintainability (R&M) of Systems and Equipment.

HIGHLIGHTS OF PREVIOUS STUDIES

Hughes Study

The Hughes Aircraft Company conducted a study, Operational Influences on Reliability, for the Rome Air Development Center (Griffiss AFB, NY, December 1976). Their findings provided interesting information regarding the logistics problems associated with reliability and the laboratory demonstrated reliability and the laboratory demonstrated reliability results.

The objectives of this study were:

1. To identify factors contributing to the reported differences between the required, predicted, demonstrated, and field observed values of reliability (MTBF) of avionics equipment currently operational in USAF aircraft systems; and,

2. To develop prediction models which would permit more valid estimates of field operational reliability.

Sixteen different avionics equipment (52 replaceable units) used on ten different USAF aircraft types were included in the study.[3]

Their findings indicated that many factors contributed to the differences and that there were no simple explanations to account for these differences. The true complexity of the problems of achieving reliability in service use was indicated from this study.

-- The MTBF for avionics equipment on subsonic bombers and transports were two to four times higher than for similar equipment installed on high performance tactical or training aircraft.

-- A base-to-base comparison of three equipments on one aircraft type, operating from nine different bases, revealed MTBF variations of as much as five to one from base-to-base.

-- The single largest factor contributing to the discrepancy between either predicted or demonstrated MTBF and field reported MTBF observed in this study was the use of aircraft flight hours (FH) for field MTBF assessments instead of equipment operations hours (OH).

-- Aircraft utilization rates (flight hours per month per aircraft) were observed to vary as much as three to one between different types of aircraft. For one equipment in the study the data indicated the 40 percent of its reported failure had occurred during nonoperational periods.

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[3] Hughes Aircraft Company, "Operational Influences on Reliability," Final Technical Report, April 1974-September 1976, by Richard Baker and George Kern, RADC-TR-76-366, December 1976.

-- A major finding of the study was that the differences were due to a combination of definitional factors (i.e., what is a failure and what is the time base?) and operational factors. Significant differences in operational reliability were observed.

-- A review of avionics maintenance resources expenditure indicated that approximately 39 percent of all maintenance action was expended on the equipment interface and associated hardware items, thereby exposing the equipment to additional maintenance handling and on-off cycling.

-- The effect of failures occurring during nonoperating time appeared to constitute a significant percentage of the total failures observed because of the relatively low utilization rates.

The following recommendations were included in this study:

1. Establish more consistent measures of reliability assessment methods.

2. Develop end-user oriented measures of reliability and maintainability characteristics.

3. Develop mathematical models for estimating field reliability as a function of demonstrated and predicted reliability.

Grumman Study

A separate 19-month study on "Evaluation of Environmental Profiles for Reliability Demonstration" was conducted by Grumman Aerospace Corp. for the same Air Force Air Development Center.[4]

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[4]George Hirschberger and Allan Dantowitz, "Evaluation of Environmental Profiles for Reliability Demonstration," Final Technical Report, June 1973-January 1975, RADC-TR-75-242, September 1975.

The primary objectives were:

1. To determine the adequacy of the environmental profiles of MIL-STD 781 in simulating field stresses.

2. Where inadequacies existed, provided recommended new test profiles for inclusion in MIL-STD 781.

Secondary objectives were:

1. To determine the adequacy and provide recommendations for improving demonstration test ground rules and scoring criteria; and,

2. To identify changes needed in reliability prediction methods to produce better correlation between test and field results. Their findings indicated: a. That the difference between laboratory tests and field environmental exposure is one of the most significant reasons for avionics estimated reliability incompatibility; b. Increased environmental stress levels on hardware due to modern high speed, high performance aircraft are responsible for many field failures; and c. That almost 50 percent of the failures experienced during the study were environmentally related (see Figure 1).

Ninety-five line removal units representing a cross-section of avionic types and applications were used in this study. The results of the study indicated that differences between laboratory demonstrated and field observed reliability was attributable to a wide variety of factors. The variance factor contribution to the reliability differences are reproduced in Table 1.

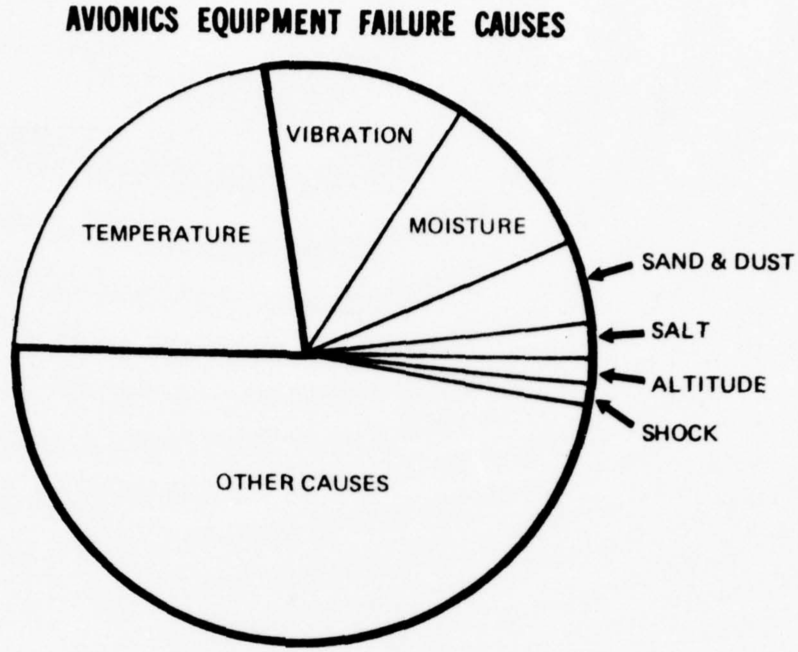

Figure 1

Highlights of the study are presented as follows:

-- Inconsistent ground rules and failure scoring criteria accounted for a significant portion of the difference between demonstrated and field MTBF. Anomalies which should be considered accountable are often excluded by demonstration test ground rules.

-- Current military logistic data reporting systems lack detail in describing malfunctions, resulting in counting incidents which should be excluded.

-- Difficulties in collecting equipment operating time data resulting in flight time being used on the time base for field MTBF determination.

TABLE 1 FACTORS CONTRIBUTING TO RELIABILITY DIFFERENCES

FACTOR	POSSIBLE REASON
ENVIRONMENT	● Limited test exposure in terms of type, duration and level.
	● Variability of in-field site conditions.
	● Dissimilarity between test conditions & operational requirements.
	● Test environment is usually controlled & benign. Constrained by test equipment capability & flexibility.
	● Potential for mishandling greater in the field.
EQUIPMENT	● Test article not necessarily representative in terms of parts, processes or materials.
	● Maturity & configuration evolution between test speciman and later production units.
	● Sophistication of peripheral test equipment to identify and localize problems.
	● Accessibility for diagnostic and corrective maintenance controlled during testing.
DATA	● Failure definition and classification of ground rules may not be consistent.
	● Accuracy and completeness is a function of personnel skill and motivation.
	● Estimation techniques inconsistencies.
	● Equipment traceability and discernment of secondary problems very limited or nonexistent.

-- Reclassification of failures, both field and laboratory.

-- Fifty percent of the equipment studies had field values three times lower than the corresponding demonstrated value.

-- The reliability agreement between the laboratory and the field was poorer on those items that had a potential for abuse in the field.

-- Those items that had the more effective burn-in testing on production units tended to have better reliability agreements.

-- There was some evidence that the current MIL-STD 781 tests of only requiring dwells at the temperature extremes with moderate rate of exchange between the units is not an adequate test.

-- The vibration test duration was found to be a poor representative of the accumulated field vibration time. The 10 minutes of Sinusoidal vibration each hour at nonresonant frequency between 20-60 Hz is not representative of the field environment, i.e., jet aircraft, the vibration environment is random.

-- Where "hi Rel" parts were used, the equipment had better correlation between field and demonstrated reliability.

-- Moisture was found to be a major source of field failure.

Some of the recommendations of the study were:

1. Revision of the demonstration test profile and method of profile construction. This would feature:

- mission profile orientation.

- variations in chamber temperatures as a function of changes in flight conditions and thus approximating compartment temperatures.

- temperature rate of change equal to flight levels.

- coupling of cooling air variation with chamber temperature variations.

2. Revision of the demonstrated test vibration profile to feature:

- random vibration for items installed in jet aircraft.

- sinusoidal sweeps for items installed in propeller-driven aircraft.

- the vibration level to approximate those in the field.

- exposure to all input frequencies up to 2000 Hz.

3. Inclusion of a humidity test that adequately reflects field environment.

4. Incorporation of precisely defined failure criteria and scoring ground rules that clearly describe those anomalies to be considered relevant and nonrelevant as well as provide the minimum conditions for reclassifying a relevant failure as nonrelevant.

5. Include an end-items quality factor and a quality assurance factor in the prediction technique.

6. Mission profile data should be developed for those items where this information is not known.

National Academy of Science Study

The Air Force Systems Command sponsored a study on Reliability in Aeronautical Avionics Equipment, 1975.[5] This study is in a

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[5]National Research Council, Reliability in Aeronautical Avionics Equipment, A Report of the Air Force Technological Tradeoffs Panel to the Air Force Studies Board, 1975.

report of the Air Force Technological Tradeoffs Panel. The concern of this panel was the cost of ownership of new weapons systems and the question of the relative cost-effectiveness of different technologies in achieving the same or overlapping military objectives. They pointed out that the lack of reliability and poor maintainability contributed to the cost of ownership in three ways:

1. The direct cost of maintaining the unreliable equipment--in labor, personnel training, spares, replacement costs, and logistics overhead.

2. Indirect cost of down-time.

3. Indirect cost of failure during a mission, including the question of pilot safety.

The study identified a need for more realistic and effective procedures for acquiring new systems, especially in a technology changing as fast as avionics is today. A new approach would be to identify the first issuance of a Required Operational Capability (ROC) as a set of objectives. These objectives should be altered and improved by an iterative process extending well into the development phase in which feedback plays a central role. This approach illustrates a central point about reliability which is too often forgotten. The point is the achievement of reliability in systems under development depends to a large degree upon the processing of information about the specific systems involved, and it is very difficult to obtain feedback data about the systems until the systems are developed. A solution to this problem depends upon a very rigorous data-gathering effort starting at the earliest stage of the development process.

Some of the specific recommendations of the study were:

-- There is a need for more failure analysis and more emphasis on reliability by the program managers.

-- The test programs need to be restructured to provide more realistic tests that approximate the field environment.

-- Conduct earlier failure analysis and subsystems tests which would provide information on failure modes that can be corrected at minimum cost.

-- There should be more post-deployment efforts to improve avionic reliability.

RAND Study

McIver and Robinson prepared a report, A Proposed Strategy for the Acquisition of Avionics Equipment, which was the result of a Rand Studies sponsored by the USAF in December 1974.[6]

Their purpose was to develop a strategy for the acquisition of avionics equipment that would improve operational reliability and reduce life-cycle cost.

The conclusions and recommendations of this study were:

-- An alternative procurement policy and management structure for integrated avionics systems.

-- An alternative procedure for avionics development.

-- The establishment of "Air Force Avionics Development Center."

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[6] D. W. McIver, A. I. Robinson, H. L. Shulman with the Assistance of W. H. Ware, A Proposed Strategy for the Acquisition of Avionics Equipment, R-1499-PR, December 1974, a report prepared for United States Air Force Project Rand.

The rationale for the first recommendation was that at the time of the report it was suggested that the Air Force had neither the appropriate policies nor the management structure necessary for the acquisition of accurate reliable equipment. The integration of the various avionic subsystems was perceived as a major problem.

Recommendations made suggested the need for a new development approach which would take into consideration the factors shown in schematic no. 1 during the acquisition cycle. (See schematic no. 1, next page.)

The third recommendation had as its rationale the need for a separate AF Avionics Development Center with a strong civilian component. This concept included manager organization and technical expertise specifically intended for avionics development and its associated reliability problem.

The civilian component would provide continuity, corporate memory, and would have a continuing responsibility for the performance of each particular piece of equipment.

General Electric Report

Selby and Miller presented a paper "Reliability Planning and Management (RPM)"[7] at the ASQC/SRE Seminar in 1970, which addressed the credibility in avionics reliability planning and acquisition. "Experience has demonstrated that to a varying degree, a reliability

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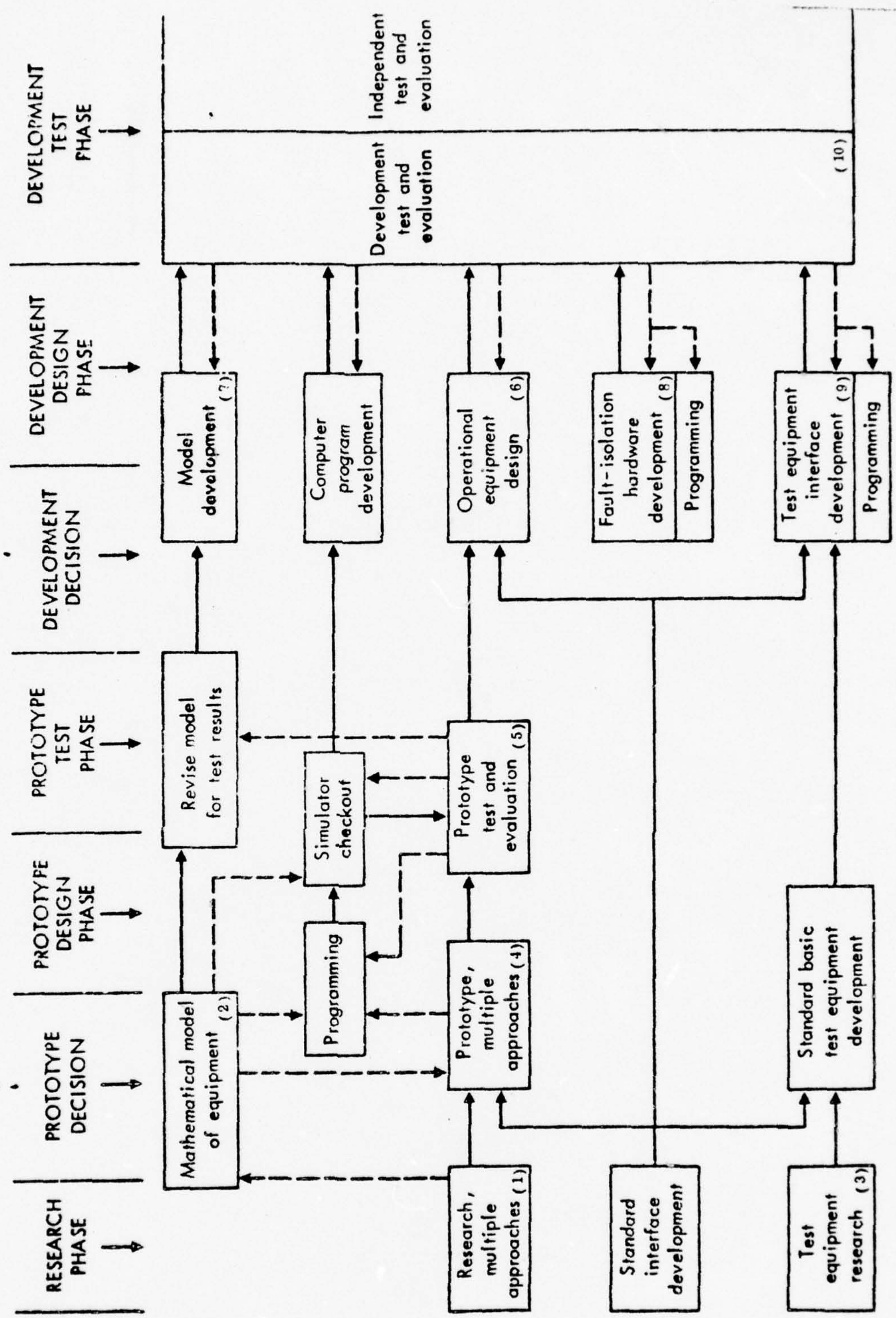
[7] J. D. Selby and S. G. Miller, "Reliability Planning and Management (RPM)," a paper presented at ASQC/SRE Seminar, Niagara Falls, NY, September 26, 1970.

ASARC I II

DEVELOPMENT ROAD MAP



Schematic No. 1

program credibility gap exists between stated equipment reliability requirements and realized achievement."[8] They suggested the gap stems largely from the lack of a uniform method of reliability program structuring and evaluation. This in turn results in the implementation of unrealistic programs with unachievable requirements. Currently, both the contractor proposal manager and the equipment buyer lack tools with which to evaluate with reasonable conviction that any of the proposed programs can result in a product compliant with the reliability requirements.

A review of the performance of avionics suppliers indicated that for the newly developed equipments in the late 1960s, the initial average achieved reliability was approximately eight percent of their specified requirements. The problem remains that "management, government and industry lack a quantitative yardstick with which to dimension, plan, manage, fund, and monitor reliability development as a part of equipment development."[9] Recognizing the past difficulties and lack of uniform success, it is mandatory that a change in the practices of Reliability Planning and Management be implemented. The authors suggested the development of a methodology which has the credibility of an exacting science, incorporates the flexibility for alternative program planning, and contains standardization factors to facilitate a uniform evaluation structure suitable for application by both contractor and buyer.

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[8] Ibid., p. 1.

[9] Ibid., p. 2.

The methodology designed by these authors called Reliability Planning and Management (RPM) reduces the planning and resource allocation requirements into a simple, guaranteed, and objectively usable format. The following factors are basic to this approach:

1. No laws of physics are violated by the designer and no beyond-the-state-of-the-art requirements are imposed.

2. The criteria to be fulfilled consisted of prediction versus requirement, initial product capability assessment, reliability growth rate, product experience gained through extended environmental exposure, calendar time, and change constraints.

3. Successful implementation requires that specific compliance be achieved for each criterion--Prediction versus Requirements, Product Capability, Reliability Rate of Growth, and Product Evaluation Exposure.

This approach, primarily a management tool, was designed to bridge the gap between stated reliability requirements and implementation planning. It is applicable to establishing plans, projecting effort, evaluating proposals and monitoring performance. It may be used equally by buyer and contractor.

SUMMARY

The highlights and findings of these studies indicate that the reliability of avionics is influenced by many factors as cited throughout these previous studies. And it's quite a challenge to improve the reliability of the complex systems and subsystems given the current budget constraints.

The emphasis on reliability is not new, emphasis on field reliability rather than statistical prediction computed for subsystem and system reliability values is a major new thrust requiring explicit attention for each program. Emphasis on field reliability focuses attention on performing more realistic tests to verify that the new systems and subsystems will perform reliably and can be supported in the field environment.

Most of the DOD Directives and MIL-STDs on reliability referenced previously are in the process of being revised. The focus now is to provide increased test realism and closer correlation between field reliability and the laboratory demonstrated reliability. MIL-STD 781C Reliability Design Qualification and Productive Tests Exponential distribution is an attempt to accomplish this objective.

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CHAPTER III

METHODOLOGY OF THE STUDY

This chapter will explain the method of selecting participants, the instrument utilized in data collection, and the method used in conducting the interview sessions.

PURPOSE OF THE STUDY

The purpose of this study was to explore reliability problems associated with engineering development (Test-Analyze-Find and Correct Phase) of avionics systems and subsystems; to examine some of the implications of the C version of MIL-STD 781; to identify some of the significant issues and problems associated with achieving reliability for avionic subsystems; and to provide recommendations that may result in improved reliability and contribute to reduction in the cost of ownership.

SELECTION OF THE PARTICIPANTS

The participants included 31 persons within the Department of Defense, industry, and the academic community who are involved in various aspects of avionics subsystems reliability.

The criteria for selecting the participants was based upon their being identified as authorities in the field and the recommendations from leaders in each area, i.e., DOD, industry, and the academic community. The numbers of participants were limited by the time constraints for conducting the study.

DESIGN OF THE INSTRUMENT

The structured interview method of data collection was used in this study. The structured interview:

1. Increases the likelihood of obtaining more accurate information.

2. Allows for clarification of ambiguous statements and collection of supplementary information.

3. Enhances the recall of relevant material.[1]

In order to obtain valid responses which reflected the intent of the research undertaken, the structured interview method of data collection was the most acceptable approach.

The following questions were used during the interview sessions:

1. What is your perception of the current DOD reliability test philosophy?

2. Do you think DOD has a common definition of what constitutes a reliable system, i.e., field reliability to the logistician may not mean the same thing to the designer or contract administrator?

3. Does the need exist for DOD to provide more guidance or a policy directive to establish a more realistic reliability program?

4. What factors, other than environmental, influence poor reliability in the field?

5. In your opinion, do we adequately monitor those factors that effect equipment reliability?

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[1]D. Miller, Handbook for Research Design and Social Measurement, 1970, p. 86.

6. Can the reliability of avionic subsystems be improved by improving the reliability test methodology during the early phase of the acquisition cycle?

7. Do we do an adequate job, contractually, defining reliability requirements (for avionic subsystems)?

8. Does the current logistic reporting system provide the kind of data from the field necessary to improve the reliability of avionics subsystems?

9. Does the DOD representative provide the equipment designer and the reliability engineer adequate information during the initial phase of the program?

10. What is your perception of our ability to provide the contractors with realistic mission profiles?

11. How much reliability consideration should be given to the conceptual and initial design phase?

12. How much consideration should be given to the reliability requirements during engineering development testing?

13. What should be the role of the Government representative during the engineering development test, i.e., test find and fix?

14. What are your perceptions of the cost impact of implementing the C version of MIL-STD 781?

15. If we implement the C version of MIL-STD 781, will we have closer correlations between lab test and field reliability data?

These questions were developed from preliminary interviews with experts in the field, based upon their experiences and reflective of their perceptions of problems, issues, and solutions to the problems of avionics subsystems reliability.

COLLECTION OF THE DATA

Initial Contacts

The researcher contacted key representatives with the DOD agencies, military test facilities managers, managers of reliability test laboratory in private industry, a West Coast University (the Graduate School for Engineering Test and Evaluation), and professional societies that have a major interest or responsibility for the reliability of avionics systems and subsystems.

These initial telephone contacts were made to discuss the objectives, time frame, and scope of the study; to explore areas of common concern; and to secure appointments for formal interview sessions. The content of these initial contacts was the basis for development of the 15 questions used as the interview guide.

Copies of the formal proposal were mailed to each participant.

The Interview Sessions

A complete explanation of the study was given to all participants at the beginning of the interview session.

The participants were interviewed in their offices and/or lab at their respective agency, during normal working hours. Those participants representing the professional organizations were

interviewed while attending the "Reliability Conference" held by the Institute of Environmental Science, Los Angeles, California.

The length of each interview was an average of four hours. In some instances, the participants also responded in writing to the 15 questions used as the interview guide. Without exception, all of the participants were highly interested in the subject.

Follow-up Contacts

Follow-up contacts were made with participants for further clarification as needed and/or for complementary data.

TREATMENT OF THE DATA

The data gathered from the interviews was analyzed by the researcher to document the various perceptions of the problems associated with improving reliability of avionics equipment, and to identify test methodologies and ways of reducing costs of testing or methods of improving reliability of avionics subsystems in the field.

A copy of this study will be provided to each agency participating and a copy to the Office of Defense Research and Engineering per their request.

CHAPTER IV

FINDINGS AND ANALYSIS OF THE DATA

This chapter reports the findings of the study. It includes a review of the data collection method, a discussion of the findings, and a listing of the participants (Figure 2), and a listing of the distribution of responses by agency (Figure 3).

REVIEW OF THE DATA COLLECTION METHOD

The personal structured interview method was used to collect the data. This approach provided the interviewer an opportunity to collect supplementary information about the respondent's professional expertise and his work environment. This added information enhanced the interpretation of the data and facilitated obtaining more accurate information than would have been by any other technique.

DISCUSSION OF THE FINDINGS

The findings of the study are presented as follows: a discussion of the perceptions held by the various experts on the subject of avionics reliability; a discussion of each question based on the responses obtained; and a summary of the data.

The various perceptions held by the participants on avionics reliability are noted as they related to the study. One part of the objective focused on the identification of significant issues and problems associated with achieving reliability for avionics systems and subsystems.

The following persons participated in the structured interviews for this study:

Name	Agency
R L Baker, Manager	Hughes Aircraft Company
J C Bear, Manager, Reliability Lab	General Dynamics, Pomona
R A Blondin, Statistician	Naval Air Facility
D A Bond, Manager	Environmental Lab, Northrop Corp.
L K Brooks	Naval Air Systems Command
Dr A Burkhard	AFFDL/FEE AFB
Dr B Campbell, Professor	California State University, Northridge
LTC S Dizek	ASD/RAOE
R E Eckel, Manager	Naval Avionics Facility
J L Gregson	Naval Avionics Facility
S Grubman	US Army Electronics Command
Dr J Guarrera, Director of Research	California State University, Northridge
P G Halamandaris, VP of Engineering	GD Electronics
W A Harmon, Jr	ASD/ENES, Wright Patterson AFB
J Hess	Cdr DARCOM
B Jones	ASD/ENO
G A Kern, Manager	Hughes Aircraft Company
J P Leslie, Manager, Reliability	Texas Instruments, Inc
MAJ P A McAdam	ASD/RAOE, Wright Patterson AFB
LTC T A Musson	HQ DA USAF, Pentagon
A Nordstrom	Cdr, DARCOM
A Pollack	HQDA, Pentagon
Dr Charles Sanders, Dean of Engineering	California State University, Northridge
W C Savage, Lab Manager	AFFDL/FEE, Wright Patterson AFB
R K Shinkle	Naval Avionics Facility
D Sinback	Naval Air Systems Command
COL B Swett	ODD R&E, Pentagon
W Wallace, Jr	NAVELEX
C Wigginton	Naval Air Systems Command
LTC W D Wilson	HQDA, Pentagon
M Zak	US Army, Electronics Command

Figure 2

Structured Interviews Participants

Distribution of Response by Organization

and Position

Organization N = 31	Response	Percentage of Total Response
US Army		
Electron Command	2	
DARCOM	2	
HQ DA ODCSDA	2	
	6	19.3%
US Air Force		
Wright-Patterson AFB		
ASD/ENO	2	
AFFDL/FEE	2	
ASD/ENES	2	
The Pentagon		
HQ USAF AF/LGYE	1	
DOD R&E (Planning)	1	
	8	25.8%
US Navy		
NAFI	4	
NAVAIR	3	
NAVELEC	1	
	8	25.8%
Industry		
General Dynamics Electronics	1	
General Dynamics, Pomona	1	
Texas Instruments, Inc.	1	
Northrop Corporation	1	
Hughes Corporation	2	
	6	19.3%
Academic Community		
California State, Northridge	3	9.6%

Figure 3

DISCUSSION OF PARTICIPANT RESPONSES RE AVIONICS RELIABILITY

The most frequently cited issues and problems associated with achieving reliability for avionics equipment, as perceived by the participants, are identified as follows:

1. The methods of comparing reliability parameters with performance parameters (for trade-off) during the acquisition process was considered inadequate, i.e., cost, weight, performance are easily quantified and measured, whereas reliability penalties have minimal impact until the equipment is deployed.

2. The existing reliability requirements are not enforced for various reasons. Examples cited included: cost and schedule. Reliability development tests are often squeezed out of the acquisition program schedule.

3. There exists a lack of clearly defined reliability requirements and a lack of emphasis on reliability during the conceptual and design phase. Some of the responses indicated that the DOD representatives do not adequately define the requirements contractually; reliability emphasis should start at the conceptual phase and continue throughout the life of the equipment.

4. Inadequate funds prevent DOD reliability representatives from participating during the testing cycle and from observing the contractor reliability techniques.

5. Inadequate fault isolation techniques were considered a major issue because of the introduction of new automatic test equipment and software problems related to that equipment.

6. The maintenance reporting system does not provide the feedback required to improve systems reliability, i.e., the typical

reporting systems operation time is used as the basis for calculating equipment failure performance. In aircraft the equipment operating time accumulated ground checkout is not considered. Other problems associated with the reporting system are failure definitions, and unscheduled calibration and maintenance which are often counted as failures.

7. Subsystems interface effects which causes other equipment failure.

8. Software programs which produce failure or the appearance of failure were also considered a significant problem.

9. A very large percentage of failures are caused by improper maintenance.

10. Increased sophistication of avionic equipment requirements and the rate of change in technology were among failure identifications listed.

11. The acquisition process and management environment was identified as part of the problem. It was suggested that a shortened procurement cycle for avionic equipment might improve reliability.

12. Other issues and/or problems identified by the participants included: increased system complexity, poor management practices, unrealistic test conditions, inadequate environmental information, and inadequate failure analysis.

These problems and/or issues identified by the participants are in addition to those discussed in Chapter II. The participants

concurred that the issues addressed in previous studies also influenced poor reliability.

The second part of the objective of this study was to examine some of the implication of implementing MIL-STD 781C.

A brief synopsis is provided for those who have not had an opportunity to review the C version of the 781. This version represents a complete revision of MIL-STD 781B. The scope of the specification has been broadened and the environments are more severe than previously required in the B version.

Some of the significant changes of the C version are:

-- Combined Environment. This approach is believed to provide more accurately simulated operational conditions. The combined stress approach (Temperature, Vibration, Attitude, and Moisture) should demonstrate reliability values which are in closer agreement with the values observed in the field.

-- Integrated Test Planning. More emphasis will be placed on integrated test planning (Table 2, Integrated Test Program).

-- Data Evaluation. A new paragraph on data evaluation will be added to assist in analyzing results of tests.

-- Stress Levels have been increased.

-- Definitions have been refined. Pattern failures have been refined.

The lower and upper limits mean time before failures have been redefined to lower and upper test between failures. The upper and lower limits are to be called out in section 3 and 4 of individual equipment specifications. Design ratio has been changed back to

TABLE 2. INTEGRATED TEST PROGRAM

EQUIPMENT PROCUREMENT PHASES					
CONCEPTUAL PHASE	FULL SCALE DEVELOPMENT		PROTOTYPE UNITS	INITIAL PRODUCTION	FULL SCALE PRODUCTION
	INITIAL DESIGN	← DESIGN MODIFICATIONS →	FINAL DESIGN	← RELEASE FOR PRODUCTION	
REQUIREMENTS STUDIED, DESIGN CONCEPTS FORMULATED, FEASIBILITY ESTABLISHED	ENGINEERING DEVELOPMENT TESTING	← FUNCTIONAL PERFORMANCE AND BURN-IN SCREENING TESTS (ALL UNITS) →			
		(A) (MIL-STD-781C)	RELIABILITY QUAL. TEST (2)	PRODUCTION RELIABILITY ACCEPTANCE TESTS (3)	
		(B) RELIABILITY DEVELOPMENT TESTING (TAAF) (1)		RELIABILITY QUAL. TEST (2)	PRODUCTION REL. ACCEPTANCE TESTS (3)
		ENVIRONMENTAL QUALIFICATION TESTS: ALTITUDE, HIGH/LOW TEMP., TEMP./ALTITUDE, VIBRATION/GUNFIRE, SHOCK, ACCELERATION, FUNGUS, SAND/DUST, RAIN, SALT ATMOS., EXPLO. ATMOS., ACOUSTIC		RELIABILITY ACCEPTANCE TESTS (3) ON BALANCE OF UNITS	

(1) TEST, ANALYZE AND FIX

(2) SPECIFIED MTBF DEMONSTRATION PER SPECIFIED TEST PLAN AND ENVIRONMENTS

(3) USUALLY LESS STRINGENT STATISTICALLY THAN RELIABILITY QUALIFICATION TESTS

(A) & (B) ALTERNATIVE TEST PLANS, (B) REQUIRES USE OF TAAF, (A) AS SPECIFIED BY MIL-STD-781C

NOTE: IF (1) TAAF TYPE TEST IS NOT DONE, (2) REL. QUAL. TEST MUST BE DONE ON PROTOTYPE UNITS

discrimination ratio with basically the same definition. The mission profile definition has been completely reworded to emphasize both span time or events and expected environmental conditions.

A significant amount of coordinated efforts took place in the development of MIL-STD 781C. A series of meetings were held: (1) within each command of the services, (2) a one-week tri-service meeting, (3) a one-week meeting between the representatives of the services and industry, and (4) meetings with the following professional societies--Institute of Environmental Science (IES), American Society of Quality Control (ASQC), National Security Industrial Association (NSIA), Quality & Reliability Assurance Advisory Committee (QRAAC).

Each professional society represented many companies and a wide variety of disciplines. For example, the IES input represented 22 separate companies and six major disciplines within each organization participating in reliability development (Figure 4).

A summary of the perceptions held by the participants regarding the implications of 781C are as follows:

-- The cost impact of implementing the C version as now proposed (30 Aug 76 draft) would be astronomical. The nonrecurring cost would be high because of the requirement for new test equipment and additional environmental facilities. The recurring cost would also be higher because of added maintenance cost coupled with the need for additional controls.

-- Concern was expressed that this would complicate fault isolation. When a failure occurs, during a combined environment

INSTITUTE OF ENVIRONMENTAL SCIENCES AND DOD INTERFACE

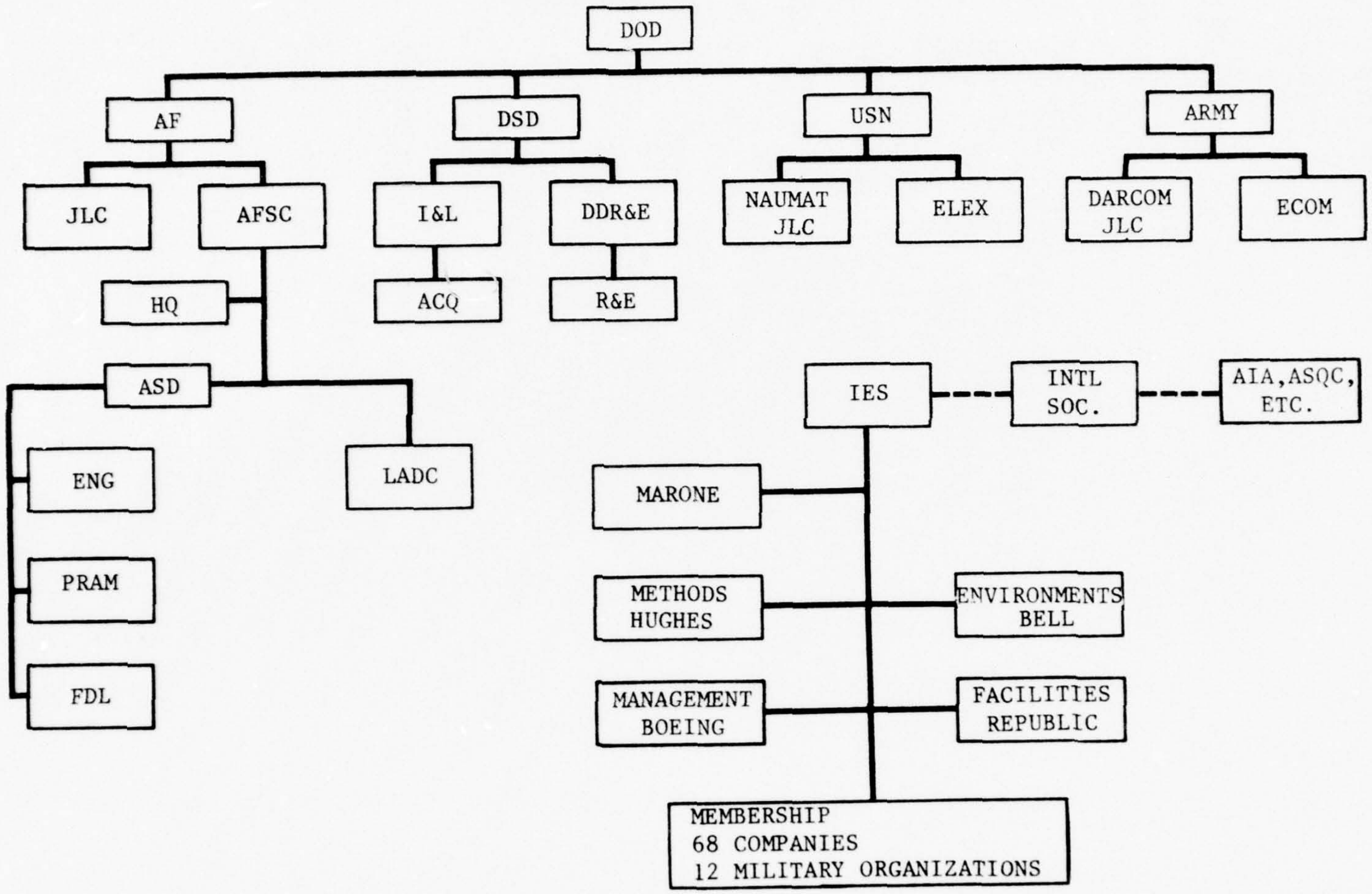


Figure 4

test, how do you isolate the specific environment that caused the failure, how much time is required to make that determination?

-- 781C was viewed by some as an unnecessary expense and unaffordable in the near time frame. There were those who believed that major improvements could be achieved at lower cost by enforcing existing specifications and improving reliability managerial practices.

-- The cost of testing would be increased maybe to the point that the program manager and other decision-makers would be encouraged to cut out some of the tests; thus less testing would be accomplished than is now being accomplished.

-- There would be no significant changes in field reliability as a result of these revisions because of the many other factors which effect reliability that were not addressed in the specification, i.e., training of maintenance personnel, improper maintenance, the maintenance reporting cycle, human engineering, etc.

-- On the positive side many favored the release and field trials of 781C. They believed the document would result in improved field reliability. The more realistic test conditions would close the disparity between lab and field reliability assessment, and the new specifications would place greater emphasis on reliability attainment.

-- Most agreed that the test cost would increase; however, it was believed that the long-range cost of ownership would be decreased because of improved reliability.

-- MIL-STD 781C would have a positive impact on reliability development procedures by forcing communications between environmental and reliability organizations, both in government and industry. It would force all engineering disciplines that should be involved in reliability development to recognize their participative roles.

-- Most of the participants agreed that 781B did not impose a realistic and/or adequate vibration environment for high performance avionics equipment. The new test levels must be reasonable and based on real requirements, i.e., they should be realistic to include mission profile for specific aircraft and possibly location within the aircraft.

The integrated test approach outlined in MIL-STD 781C was viewed by some as a positive step toward achieving the DOD goal of reliability improvement of weapons systems (See Table 2, Integrated Test Program, from the August draft of MIL-STD 781C). (See p. 38.)

The third part and the primary focus of the study was to explore the reliability problems associated with engineering development (Test-Analyze-Find and Correct Phase) testing of avionics subsystems and equipment; and to attempt to provide recommendations that may result in improved reliability and contribute to reduction in the cost of ownership.

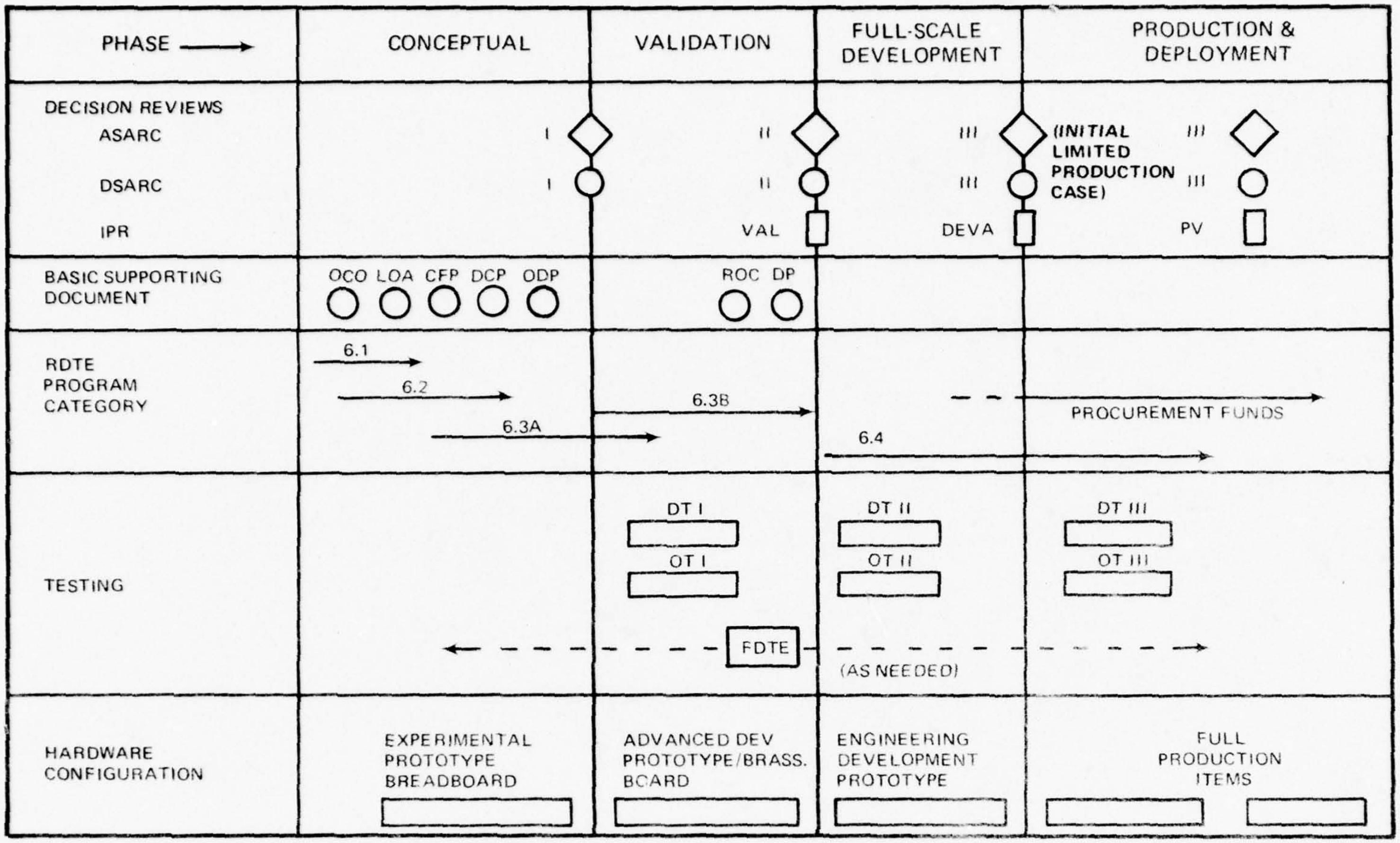
The materiel acquisition process and the total managerial environment was frequently cited as part of the problems associated with avionics reliability. A brief review of these two areas is presented below. The basic acquisition process is a sequence of

specific phases of program activity and decision points.

An overview of the key phases and decision points is presented in Chart 1, System Acquisition Model. Each phase of the process has as its underlying objective the progressive refinement and quantification of the technical, economic, and schedule projections that are the basis for system requirement.

Chart 2 is representative of the management environment associated with the procurement process. This specific chart represents the Army's management structure. Each of the services has a similar structure.

Engineering development is a part of this total acquisition process. Engineering development testing and planning as a part of the phase should be continuous throughout the development cycle. The purpose of Engineering Development Testing is to reduce risks as early as possible. The participants agreed that it should include laboratory tests, operational testing and systems and subsystems demonstrations. The planning for these tests should be as early as possible in the System Acquisition Phase. The program manager must evaluate the tactical importance of the specific requirements relative to the design state-of-the-art, program scheduling, funding constraints, availability of test facilities and other factors before he can define the specific test requirements. He also determines the reliability failure characteristics before selecting the particular test method. An example of a nominal development phasing is shown in Figure 5. This nominal development phasing shows Reliability Demonstration Growth Test



ASARC–Army Systems Acquisition Review Council
DEVA–Development Acceptance
DSARC–Defense System Acquisition Review Council
DP–Development Plan
DT I (II) (III)–Development Test I (II) (III)
FDTE–Force Development Testing and Experimentation
IPR–In-Process Review
LOA–Letter of Agreement
OCO–Operational Capability Objective
ODP–Outline Development Plan
CFP–Concept Formulation Package

OP (I) (II) (III)–Operational Test I (II) (III)
PV–Production Validation
ROC–Required Operational Capability
VAL–Validation
PROGRAM CATEGORY:
- 6.1–Basic Research
- 6.2–Exploratory Development
- 6.3A–Advanced Development (Non-system)
- 6.3B–Advanced Development (System)
- 6.4–Engineering Development

CHART 1: SYSTEM ACQUISITION MODEL

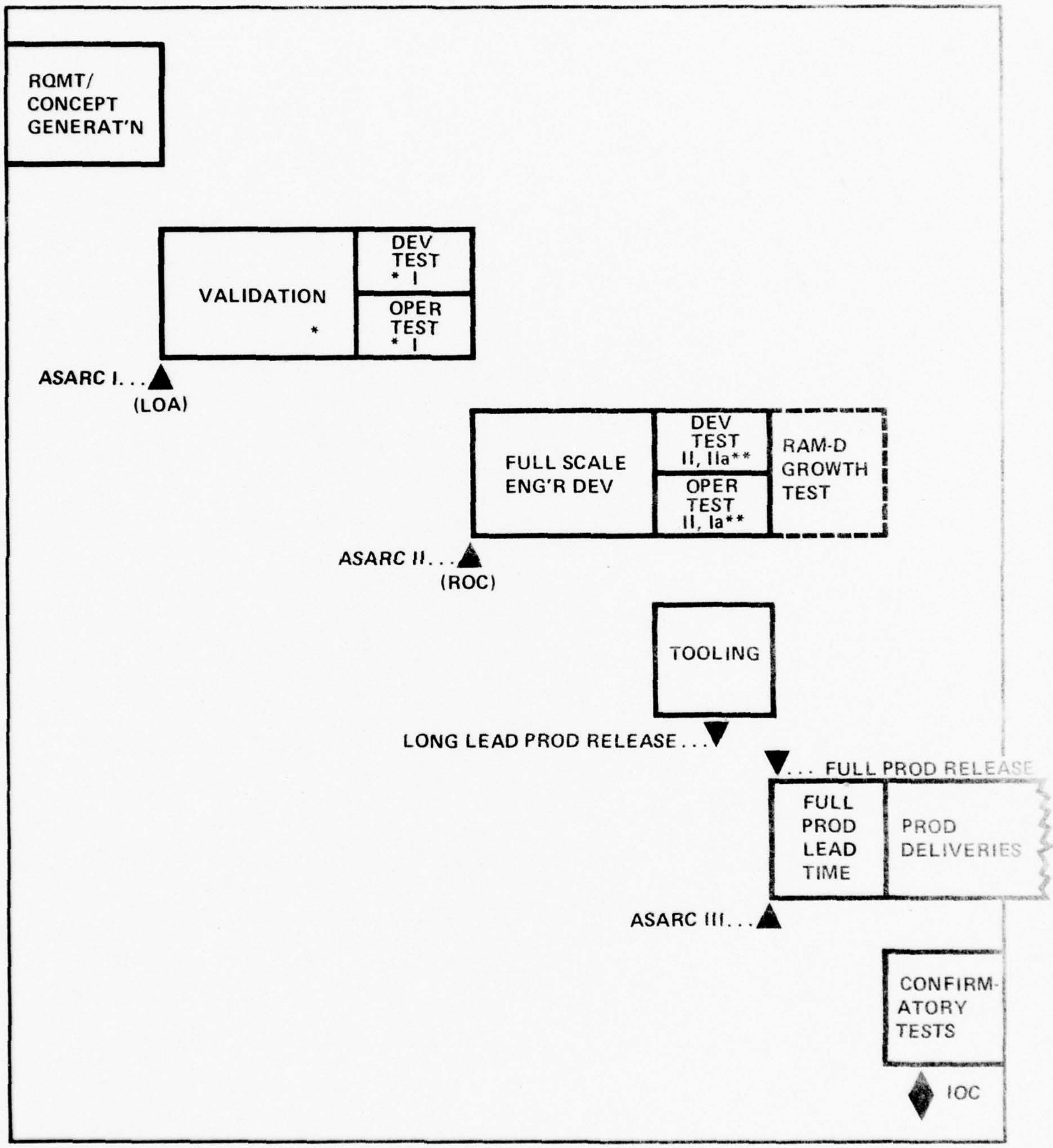
MANAGEMENT ENVIRONMENT

° ARMY STAFF	° DCSRDA:	TOTAL ACQUISITION RESPONSIBILITY
	° DCSOPS	OPERATIONAL REQUIREMENTS, COEA
	° PA&E:	FORCE AND FISCAL GUIDANCE
° ARMY SECRETARIAT	° US of A:	IN CHARGE OF ACQUISITION
	° DUSA(OR):	'NEW LOOK' FOR COEA, OPERATIONAL AND FORCE DEVELOPMENT TESTING
	° ASA(R&D):	NEW APPROACHES TO CONTRACTING, QUESTIONS TESTING POLICY, PROGRAMS TOO LONG AND TOO EXPENSIVE, TAKE SOME RISKS
	° ASA(I&L):	PROCUREMENT POLICY
° OSD	° DDRE:	POLICY LEVEL - MISSION AREA DEFICIENCY AND MANY APPROACHES (6.3) WORKING LEVEL - PROGRAM "INVENTORS"
	° PA&E:	COEA, FORCE TRADEOFFS, PROGRAM "INVENTORS"
	° COMPTROLLER:	FISCAL CONSTRAINTS
	° ASD(I&L):	CURRENTLY PRODUCTION BASE ORIENTED, WITH OSD REORGANIZATION-?
° CONGRESS	° STAFFS:	INCREASING POWER AND DEMAND FOR INFO
	° MEMBERS:	MIXED BAG. CONFUSION OVER ROLES OF VARIOUS COMMITTEES
° THE FIELD	° DARCOM-	REORGANIZATION UNDERWAY, DA DIRECT LINE TO SUBORDINATE COMMANDS
	° TRADOC-	LOA VS. ROC APPROACH
	° TESTING-	DT, OT, FD; TOO LONG

CHART 2

FIGURE 5

Nominal DEVELOPMENT PHASING



* NOT NECESSARY WHERE TECHNOLOGY IS VERIFIED AND REQUIREMENT CERTAIN

** CONDUCTED WHEN SIGNIFICANT DEFICIENCIES FOUND

at the end of development and operation ll tests. It is the position of this researcher that reliability planning should start at the Requirement Concept Generations Phase and that informal tests to identify failure should start as soon as you have hardware. The Engineering Development Test program should be designed to reduce risk as early as possible, to demonstrate that the Engineering design and development process is complete, to verify the attainment of technical performance specifications and objectives, and to demonstrate that the design risks have been minimized.

Most of the participants agreed that the best time to improve reliability is during the Engineering Development test. Unfortunately the typical situation is that the customer has not had the budget and time required to do the development testing properly. The contractors are asked to build a flyable prototype which has poorly defined reliability requirements. Then, if the prototype is successful, production units are procured on an FFP contract in the shortest time and lowest cost possible. This approach does not support the overall DOD reliability goal.

During engineering development testing the following should be major considerations:

-- Are the systems and subsystems requirements detailed to the ROC? Does the design approach take into consideration reliability requirements and supportability?

-- Have the MTBF been specified, and is it based on realistic requirements?

-- Are there communication channels for resolving unrealistic requirements?

-- Have the MTTR been established?

-- Have contracts been established for technical performance measurement, failure modes and effective analysis and integrated logistic support?

-- Are funds and schedules adequate to conduct those tests necessary to test-analyze-find and correct differences?

-- During the Engineering Development Phase, the reliability growth plan should be a major consideration. The reliability growth management plan should include as a minimum these elements:

1. A description of the sources of historical data used in preparing the planned growth curves.

2. The Engineering rationale used in deriving the planned growth curves.

3. A process for identification and elimination of failure modes, including the resources to be used in these activities.

4. Systems and critical subsystems planned growth curves.

5. A method for assessing reliability at successive points in time and comparing these assessments with the planned growth curves.

Most of the personnel interviewed agreed that Environmental Development Testing Phase should include sufficient tests to provide confidence that the equipment will operate satisfactorily in the intended use environment. These tests should also include 0 exposure to individual environments and combinations of environments where it is economically feasible. The participants also agreed that the reliability testing during the Engineering Development Phase should include sufficient testing to provide confidence that

the equipment meets or exceeds the theta 0. A test-analyze-find and correct approach should be used to analyze all failures incorporating corrective action and restating. During this period the government representative should be fully involved with the contractor in attempting to resolve problems--not counting failures.

During the researcher's visit to Wright-Patterson AFB, Flight Test Lab, several hours were spent observing tests in progress and discussing the overall Combined Environmental Reliability Test (CERT) evaluation program. This program consists of a series of tests of avionics equipment which evaluates the technical merit of conducting reliability tests with combined environments. These environments included random vibration, humidity, temperature, altitude, and air flow. The Combined Environment Reliability Evaluation Program is divided into three phases:

1. Establish technical merit of CERT.
2. Evaluate cost effectiveness of CERT.
3. Implementation planning.

The facility used at Wright-Patterson AFB is a special design facility. The design, fabrication and performance of this experimental test facility has been reported in the referenced document.[1]

The participants all agreed that the cost of facilitizing to perform these tests will be very expensive and raise many questions of cost evfectiveness.

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[1]A. Mayer and D. Prather, An Experimental Facility for Dynamic Combined Environments Reliability Testing of Airborne Equipment, AFFDL-TR-76-108, 1976.

One-third of the 15 questions were related to this part of the study. The specific responses to these questions are included in the overall distribution of responses.

The perceptions of the participants in this study are reflected in their responses to the following 15 questions. These responses do not represent completely the opinion of any one DOD agency or industry, nor all of the participants. It does attempt to represent a summary of the various perceptions held by the participants. I hope that my conclusions and recommendations will be of value in influencing the content of the reliability document currently being revised, to improve the overall reliability of military weapon systems, and possibly lead to a reduction in the cost of ownership.

PARTICIPANTS' RESPONSES TO SPECIFIC QUESTIONS OF THE STUDY

The remainder of the chapter presents responses from the participants to the 15 questions presented.

1. WHAT IS YOUR PERCEPTION OF THE CURRENT DOD RELIABILITY TEST PHILOSOPHY?

Responses

__ The current philosophy is more directed toward compliance to military standards and specifications rather than towards the equipment reliability.

__ One which has over-emphasized expensive techniques for laboratory testing with little or no appreciation of the enormous burden it will place on DOD activities, or the manner in which the contractors can undermine it.

__ I believe it to be unnecessary, expensive, and ineffective--yet one which ignores very real opportunities to achieve considerable improvement at relatively little cost.

__ Can't speak for DOD overall philosophy. I have trouble thinking above our command. I don't think there is a DOD reliability test philosophy--and I don't think that's a problem.

__ I don't know.

__ A philosophy that depends almost exclusively on "Test-Find and Fix" to control reliability.

__ A philosophy that places too much emphasis on testing and not enough on design.

__ Not sure.

__ The reliability test philosophy is as defined in DOD Directives 5000.1-3 and it is becoming more realistic and can be tailored to suit the acquisition strategy on a case by case basis.

__ One that is improving.

__ A philosophy that drives by cost and schedule.

__ One that fails to address the many factors that influence reliability.

__ A philosophy that is effective for very large or major programs but not effective on small programs.

__ No. But what we need is a common design philosophy--that's the key issue. Test plans or test philosophy won't solve the problem. We need a type design engineer that understands the problems of his technologies he's working with. Reliability should be a religion for every design engineer.

2. DO YOU THINK DOD HAS A COMMON DEFINITION OF WHAT CONSTITUTES A RELIABLE SYSTEM, i.e., FIELD RELIABILITY TO THE LOGISTICIAN MAY NOT MEAN THE SAME THING TO THE DESIGNER OR CONTRACT ADMINISTRATOR?

Responses

__ No. Not a common definition.

__ No. However considerable effort is being made to improve the definition problem.

__ We will have a common definition if, and only if, the definition of the RAM parameters are understood by all.

__ Yes. I think the definition of a reliable system is generally the same throughout DOD, and that is how long does the equipment operate under mission environment?

__ No. No common perception of field problems reliability.

__ No. A considerable area of difficulty exists just because of these conceptual differences.

__ No.

__ Yes.

__ No. I think we have confused a bunch of people.

__ At present, the DOD does not have a common definition of what constitutes a reliable system. The present way that reliability is specified in contractual documents and how the equipment is demonstrated are not compatible.

3. DOES THE NEED EXIST FOR DOD TO PROVIDE MORE GUIDANCE OR A POLICY DIRECTIVE TO ESTABLISH A MORE REALISTIC RELIABILITY PROGRAM?

Responses

__ Yes. But it should be guidance--not a "how-to (cook book)." By providing a DOD directive, it should give the program the high level authority it needs.

__ No. More guidance would be more harmful than helpful.

__ Yes. We need broad guidance with options.

__ Yes. More management emphasis.

__ Yes. Realistic is the key word. The "conventional wisdom" of what wrong with the current program is dangerously misinformed; for example, there is virtually no real understanding of just why equipment in the field fail and without such understanding we can only provide opinions of what should be done to fix the system (no matter how widely subscribed to).

__ Yes.

__ Yes. And I think one is being written.

__ No. We need better understanding of the existing guidance.

__ Yes. The existing reliability documents should be pulled together and the proposed DOD Directive should provide this guidance.

4. WHAT FACTORS OTHER THAN ENVIRONMENTAL INFLUENCE POOR RELIABILITY IN THE FIELD?

Responses

__ Integrated Logistic Support, Maintenance Support, Operations and Support Cost.

__ System Interaction Effect--equipment which causes other equipment to fail.

__ Software which produces failure--or the appearance of failure.

__ Improper maintenance which causes more failure than natural.

__ Equipment delivered to the field which does not have the reliability characteristic which should have resulted from the design/test effort.

__ Cost cutting schemes in the Procurement Cycle.

__ Inadequate and insufficient field test or early feedback from field deployment.

__ Tech orders that have not been thoroughly checked out.

__ Inexperienced personnel (operators).

__ Interface problems.

__ Failure definitions.

__ Inadequate reporting system.

__ The environmental factors are the major contributors to the unreliability of equipment. Other factors which influence poor reliability are:

a. Ease of equipment repair. Our equipment which is easily disassembled, repaired and checkout is less likely to be "screwdrivered" and damaged.

b. Misapplication of the equipment. If the equipment is designed to perform a specific task, it should not be used for other applications.

5. IN YOUR OPINION, DO WE ADEQUATELY MONITOR THOSE FACTORS THAT EFFECT EQUIPMENT RELIABILITY?

Responses

No. Lack of funds prevent participation and observation of the reliability techniques.

No. Lack of clear R&M definitions and difficulties in writing specifications.

No. It is difficult to enforce reliability requirement under the current DOD acquisition system because of the heavy emphasis on cost schedule or aircraft flight conditions.

— During the production phase, yes it is monitored adequately; however, we need a better system for monitoring the repair and maintenance cycle.

— No. They don't seem to have enough adequately trained personnel in the field of reliability.

— No, not adequate job. The Air Force in my opinion works closer with the developer than the other two services.

— No. All of the Service reliability monitoring and data collection are poor at best. Great strides in equipment reliability can be made with proper documented failure data from the field and other programs. Once the problems is identified, the corrective action is easy.

6. CAN THE RELIABILITY OF AVIONIC SUB-SYSTEMS BE IMPROVED BY IMPROVING THE RELIABILITY TEST METHODOLOGY DURING THE EARLY PHASE OF THE ACQUISITION CYCLE?

Responses

__ Yes. The use of Reliability Test during the Engineering Development Phase of Avionic equipment can prove the ultimate reliability of the system.

__ Yes. Front-end lead the RAM testing through design, more dedicated funding.

__ Sure. It is the most cost effective approach.

__ Yes. However, the first goal should be to adhere to 781B test philosophy because the most serious problem in existing equipment can be treated to abuse of the currently published (781B) requirements.
Second goal should be improvement of existing requirement and documents.

7. DO WE DO AN ADEQUATE JOB, CONTRACTUALLY, DEFINING RELIABILITY REQUIREMENTS?

Responses

__ They are beginning to do a much better job defining reliability requirements and I think the new DOD Directive 5000.X will help them do even a better job.

__ Yes; they do a good job defining Reliability contractually, but the real question is how realistic is the MTBF number. I don't think they do a good job in establishing what that MTBF should be.

__ No. I think we need to improve in this area and I think we are improving.

__ No. However, there is a Joint Technical Coordination Group on Electronic Systems reliability working to improve the situation.

__ No. Definitely not.

__ I think the overall opinion is no, for any type system.

__ No. There is a difference between Services, but within the Service we still find the same kind of variance.

__ Yes. MTBF requirements are defined in the correct number, but they are not based on analysis of the operating environments.

__ No! The total field is never identified MIL SPE call out such as MIL STD 810 and MIL-E 5400, Class 0 equipment does not define all the environmental requirements. The government must identify all of the factors which effect equipment reliability.

8. DOES THE CURRENT LOGISTIC REPORTING SYSTEM PROVIDE THE KIND OF DATA, FROM THE FIELD NECESSARY TO IMPROVE THE RELIABILITY OF AVIONICS SUB-SYSTEMS?

Responses

__ No. Leaves a lot to be desired.

__ No. Only through sample data collections, obtaining reliability data on fielded equipment is expensive and most maintenance personnel are not trained to prove that kind of data.

__ No.

__ Definitely not. There are many problems and issues in this arena. The most serious is the absence of any good effort to provide.

__ No. The type of data now being reported is fine for identifying trends and for logistic support, but the kind of data required for engineering or reliability improvement does not exist.

__ No. Many of the failures counted in the field are caused by maintenance personnel.

__ No. Obtaining engineering data from the field will always be difficult, but to not go to the extra expense and effort during early deployment to gain insight into reliability and engineering problems is to miss a valuable opportunity.

__ This is currently a problem area.

__ No. Data requirements should be tailored to system complexity and specific needs.

__ No. Failure definition was identified as part of the problem. The reporting forms vary with each service for a given system.

9. DOES THE DOD REPRESENTATIVE PROVIDE THE EQUIPMENT DESIGNER AND THE RELIABILITY ENGINEER ADEQUATE INFORMATION DURING THE INITIAL PHASE OF THE PROGRAM?

Responses

__ No. There is a definite need for the DOD reliability representative to work very close with the developer--specifically the designer and the reliability to make all of the information required of the system--Environmental and Operational requirement. This should include the maintenance required and the level of training of the equipment operation.

__ No.

__ Can only speak to our situation--not all DOD--and the answer is no. But I don't consider it a major deficiency.

__ No. This is the program manager's job. Maybe he needs a reliability handbook and some training in reliability and cost trade-off.

__ Yes. I think the requirements such as mission profile on new systems should be the developer's responsibility and we should provide funds for it through the contract.

__ No information is required on the total environment, including the operating mode, specific location in the aircraft, the capability of the maintenance support personnel.

__ No. The need exists for a reliability and maintainability data base and this information should be available to all contractors so that working with the Services the contractors could also contribute to this data base.

10. WHAT IS YOUR PERCEPTION OF OUR ABILITY TO PROVIDE THE CONTRACTORS WITH REALISTIC MISSION PROFILES?

Responses

__ The AF and Navy have improved in this area. I have not had enough experience with the Army to comment on the Program.

__ Improving, but they still have a long way to go. For example, the Air Force at Wright Patterson may have to develop a technique or compile a good data base and the other service may have no knowledge of this capability.

__ The capability exists. More funds or emphasis is required.

__ Inadequate because it is hard to obtain data from the field during early deployment.

__ Inadequate because of budget constraint.

__ Fair, the new MIL-STD 781C should improve this situation.

__ Not a very good job. The MTBF selected quite often is not based on realistic requirements.

__ Very limited.

__ On the F16 Program we established a mission profile based on our knowledge of the aircraft utilizing the assist of our pilot. The Air Force personnel worked with us drawing on their experience of other systems. The capability exists to provide the information, but what is required is an information exchange program for the existing data. It's my observation that very little of the information available is being shared.

11. HOW MUCH RELIABILITY CONSIDERATION SHOULD BE GIVEN TO THE CONCEPTUAL AND INITIAL DESIGN PHASE?

Responses

__ As much as possible. This is where the planning and trade-off begin. You increase your cost by not considering the reliability requirements during the conceptual phase.

__ As much as possible the planning and testing is vital during this phase of the program.

__ This is where the reliability requirements should begin to take shape. Attempts should be made to review like systems in the field. The requirements and the reliability assessment methods should be clearly defined.

__ The conceptual and initial design phase is where the basic decisions on the approach to obtain the specific reliability requirements is developed. The thermal design outline and part selection approach is established.

__ Follow the guidance of MIL-STD 785, it's adequate for the conceptual phase.

__ More consideration than we are currently giving.

__ Depends on the type of program, if it is major or xmall box. We are more in favor of growth kind of approach, where you uncover problem areas and you either fix it or identify the fix and not get involved in a bean counting game. A pass fail criteria should be established. The test method should be one of uncovering weakness, design deficiencies, and provide a procedure for resolving failures.

__ During the conceptual phase we should be establishing the design requirement and test approach necessary to ensure that the equipment will meet the pre-production reliability demonstration test.

__ Quantitative R&M requirements should be established, these values should be based upon realistic user requirements giving due consideration to the weapon systems mission profile and minimum essential operational needs in the anticipated environment to include optimizing the life cycle cost.

12. HOW MUCH CONSIDERATION SHOULD BE GIVEN TO THE RELIABILITY REQUIREMENTS DURING ENGINEERING DEVELOPMENT TESTING?

Responses

__ As much as you can, you start your testing as soon as you have hardware, burn in at the earliest phase possible, many design problems are possible.

__ Both the contractor and the Government should be working as a team in planning reliability and assessment techniques to allow for anticipated achieved reliability.

__ The reliability consideration should have started during the conceptual phase; at this phase of the program you should be conditioning those tests that will provide data for timely tow-risk full-scale development of the new system. For example, Breadboard model mock-up test, engineering developed hardware test, prototype hardware test, early production hardware as a continuous process.

__ More than is currently given to reliability consideration.

__ As much as possible both the reliability requirement and testing during this phase is vital to success.

__ No consideration, or practically no. It could be counter productive for many (but not all) programs assuming the goal is to find and fix as many engineering problems as possible during this phase and not to count failure or be concerned with correlation of laboratory vs. field data.

__ The emphasis on reliability should be applied most heavily during Engineering development tests. This is the phase where the most cost effective corrections can be accomplished. Failure modes can be identified and corrective actions developed, design changes can be made.

__ Reliability on the total RAM requirement should be the most critical issue in all DCPs. That's the only way it ever will succeed.

13. WHAT SHOULD BE THE ROLE OF THE GOVERNMENT DURING THE ENGINEERING DEVELOPMENT TEST, i.e., TEST FIND AND FIX?

Responses

__ Deeply involved with the contractor in a role of assisting in the process of identifying and finding solutions to failure; not one of counting the number of failures.

__ The DOD involvement can be very helpful in that it encourages managers to provide support in seeking solutions to problems. Industry and the DOD representative should work as a team.

__ A member of the team. Both representatives must be qualified and reasonable people. If the DOD representative can only quote regulations and count failures, he can cause serious cost and schedule impact.

__ HELP find and FIX in the role of a member of the team.

__ Establish guidance, monitor development and make recommendations for improved reliability.

__ *Provide the incentive for the contractor to find and fix as many* failures as possible.

__ Work more closely with the developers during this phase and assure that adequate funds are available to correct problem identified.

__ When it becomes necessary, be sure top management allows adequate time to take corrective action, and management emphasis.

14. WHAT ARE YOUR PERCEPTIONS OF THE COST IMPACT OF IMPLEMENTING THE C VERSION OF MIL-STD 781?

Responses

__ Increase in test cost but should produce a more reliable system.

__ Increase facility and test cost. May encourage program managers to eliminate some of the test because of the increased cost.

__ The cost impact will be astronomical. The main reason for the increase will be new facilities, test equipment and maintenance.

__ Cost of testing will be too high (see Naval Avionics Facility Report).

__ The test cost will go up and the first programs will have to pay for the increased facility cost. See special cost summary put together by the Institute of Environmental Sciences.

__ The long-range overall cost will be less. The initial test cost will be increased.

__ The use of mission/environmental profile to determine the equipment specifications should lead to more realistic test and result in an overall cost of ownership.

__ We don't know. At present we are conducting the CERT evaluation program here at Wright-Patterson. Part of the objective is to assess technical merit of combined reliability testing and evaluate the cost effectiveness of this type of approach. We are taking a good look at cost, to include ways of reducing facility cost. Upon completion of test tasks, we will provide implementation instructions and plans.

__ I have seen a cost of studies and I think it is too early to know what the real cost impact will be. The initial test cost and the additional facilities will increase the cost considerably.

__ The Air Force should be better qualified to answer the cost impact because they are currently making comparisons of the cost by conducting CERT test approach relative to the current reliability and environmental test of avionics equipment. Capital investment is being considered in this evaluation.

__ The Institute of Environmental Sciences made a nationwide study of the cost impact which reflected the increase facility cost. I have forgotten the exact amount, but it will be high.

15. IF WE IMPLEMENT THE C VERSION OF MIL SPECIFICATION 781, WILL WE HAVE CLOSER CORRELATIONS BETWEEN LAB TEST AND FIELD RELIABILITY DATA?

Responses

__ That is a big concern of mine that some people in DOD think we are to go out and do this, combine environmental requirement of 781C and end up with MTBF in the test program that we see in the field. I do not think that will be true. I think that three or four years from now, when we start getting the 781C result, we will ask what went wrong. I do think we will be in better shape. But it will not correct the problem COL Swett originally uncovered in his Phase I Study.
The disparity between field reliability data is due to a great number of things, some of which are environmental.

__ Yes. Because of increased test realism.

__ No. There are too many variables not covered by the 781C.

__ No. I think there is an over emphasis on testing and not enough on design.

__ Yes, there is no doubt about the C version going to do a better job. The integrated test approach and the more realistic test approach should provide closer correlation of laboratory reliability and field reliability data.

__ The use of mission/environmental profiles to determine the equipment should result in a much more realistic test and closer correlation of field and lab test results.

__ The Reliability, Qualification and Acceptance Tests are carried out under the combined environmental conditions of electrical input, temperature, vibration, and humidity with the specific test level to be derived from the mission and environmental profile for the specific equipment. This will result in closer correlation.

__ We hope so, but we are currently conducting the CERT evaluation program to determine the technical merit of the type of lab test as outlined in 781C. When these tests are complete, we will compare the results. At present I would rather not predict the outcome.

__ Yes, but not much closer because of the logistic reporting system.

CHAPTER V

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

The role of Reliability and Environmental Engineers in the past has been traditionally a limited, supportive one. This assumed role was accepted by top management and decision-makers in the military and industry. Until recently, very little effort was made to integrate their expertise early in the acquisition process even though many of the decisions required their technical expertise. It was not until DOD established an intensive program to understand and follow-up on the means to significantly improve field reliability of complex weapons system that we began to see changes in these practices.

These changes are coming about as a result of such issues as the need to reduce support cost, increase equipment readiness, and improve overall reliability of new weapons systems.

This study identified some of the more significant issues and problems associated with these changes in achieving improved reliability for avionics systems and subsystems.

SUMMARY

The purpose of this study was to explore first some of the issues and problems associated with reliability for avionics systems and subsystems; and second, to examine some of the implications of the C version of MIL-STD 781; also, to explore the reliability problems associated with Engineering Development

(test-analyze-find and correct) testing of avionics subsystems and equipment. Additional research was conducted to provide recommendations that may result in improved engineering development test approaches and contribute to reduction in the cost of ownership.

The study considered the broad principles recommended by earlier investigations and attempted to obtain specific data which would lead to approaches that will enhance the existing reliability test approach during Engineering Development testing, and possibly lead to a reduction in operation and support cost for avionic equipment.

Problem areas have been identified and an attempt made to assess the magnitude of the problems and to determine their principal causes.

In addition to the series of previous studies conducted on avionics equipment reliability, the Joint Logistics Commanders and the Joint Technical Coordinating Group for Electronics Systems Reliability has recently established the following task groups: (1) Reliability Engineering data requirements and collection, (2) Reliability test and analysis, (3) Reliability acquisition management, (4) Software Reliability, (5) Reliability Design, and (6) Reliability Training. These groups are addressing many factors which contribute to low operational reliability. These factors include steadily increasing system complexity, poor management practices, inadequate documentation, unrealistic test requirements and procedures, poor design practice, unrealistic environmental requirements, and software errors. These factors are in concurrence with the findings of this study.

CONCLUSIONS

The conclusions reached suggest a number of areas for improvements. I have had the rewarding task of reconciling the well-considered and differing perception of the participant responses. These conclusions do not represent completely the opinions of any one agency nor all of the opinions of the participants. The conclusions and recommendations represent the viewpoints of the researcher which takes into consideration inputs from all of the participants.

The conclusions of the study are:

1. There was evidence that no standard methodology exists for developing comprehensive reliability test environments. This lack of methodology is reflected in inadequate reliability test environments which result in a set of performance and test criteria which is not representative of the true mission requirements of the equipment.

2. There was evidence that the reliability requirements and acquisition decisions related to avionics systems and subsystems are defined in terms of performance, physical characteristics, cost, quantity and schedule in conformity with the perceived threat and need. The overall requirements of the acquisition and decision process includes attention to all of these components; however, the current approach appears to be driven by cost and schedule only, with inadequate consideration given to reliability in the early phase of the acquisition and decision process.

3. That inconsistencies exist between the services' maintenance reporting system (Navy, 3-M; Air Force, 66-1; and the Army,

TAMMS) for calculations of reliability. At present each of the three services has its own reliability standards (see Appendixes B, C, D). The typical service maintenance reporting system operating time is used as the basis for calculating equipment failure performance. This is considered a significant problem area.

4. There is evidence that the need exists for more failure analysis, time and funds for engineering development testing of avionics equipment.

5. The need exists for top management in industry and DOD to continue to transmit their concern for improved reliability and provide proper managerial emphasis throughout the development process.

6. There is evidence that the existing test program MIL-STD 781B needs some restructuring. The current environmental requirements are not realistic for most avionics equipments.

7. The need exists for a comprehensive analysis and definitive program to be carried out on hardware and software for new avionics during the conceptual and validation phase, prior to full-scale development. At present inadequate considerations are given to reliability requirements for avionics system during the conceptual design and planning phases.

8. There is some evidence that the need exists to formulate a procedure which will define what a reliability test should include during the Engineering development, and where environmental data resides; how to formulate a procedure and how it should be incorporated into a contract.

9. That the reliability of avionic subsystems and systems can be improved by improving the reliability test methodology during the early phase of the acquisition process.

10. The need exists to perform more reliability analysis, to include failure rates, cause of failure, failure mode and effect analyses, and to review subsystem allocations to the equipment level and verify feasibility of the allocated requirements.

11. The contractors are not being provided the information they need to design equipment for reliable performance in field service.

12. More emphasis should be placed on reliability growth during Engineering development.

13. There is a marked absence of DOD management policy guidance regarding a comprehensive approach to reliability testing for avionic equipment.

The findings outlined in Chapter IV provide some means of understanding the nature of the problems associated with avionics reliability. The task of integrating performance, reliability, and environmental considerations into a rational approach that complies with existing DOD policy is an acute challenge.

RECOMMENDATIONS

Following are recommendations for making more effective use of existing test time and possibly improving avionics equipment field reliability. These recommendations are based on data obtained from the study.

1. DOD provide guidance that will result in a standard methodology for developing comprehensive reliability test environments. This can be accomplished by ensuring that the military departments are responsible for:

a. Establishing realistic environmental requirements. The requirements should be based on mission/environment profiles that are derived from the life cycle profile as defined by the stated operational requirements for the avionics systems or subsystems.

b. Ensure that there is adequate coordination between the operating, developing, and supporting commands.

c. Provide contractors with <u>all</u> information that influences test criteria and performance as early as possible.

2. More emphasis be placed on reliability requirements during the conceptual phase or early in the acquisition process. This can be accomplished by defining the reliability requirements as early as possible and have industry to comment on draft RFP before a competitive quota is prepared.

3. DOD evaluate the current logistic reporting system as it relates to reliability. These two areas are so different it would be appropriate to investigate the specifics of each area in detail and develop the methodology and criteria that would provide an independent assessment of mission and logistic MTBF performance. Failure definitions and failures that occur during nonoperating time should also be investigated.

4. Adequate time and funds be made available in the early part of the program to test-find and correct deficiencies; and that more time be made available for failure analysis to determine the causes of the failures.

5. The management environment be reevaluated to ensure that proper emphasis is placed on reliability. The management environment be streamlined so that the program manager can run the programs without requiring decisions from several people who are not accountable or responsible for the program, similar to the management environment in private industry.

6. Environmental requirements for avionics systems, including subsystems, be based only on mission profiles. This profile should take into account the life cycle profile as defined in the operational requirement for the equipment.

7. Identify each location of each subsystem of avionics equipment in the deployed aircraft, i.e., the wing vs. the cockpit.

8. Obtain flight profiles data from other aircraft carrying similar equipment. Many of the subsystems will fly on different aircraft and have multi-missions.

9. More emphasis and detail planning for reliability to be accomplished during the conceptual phase. Software and hardware testing and requirement definitions should also be given more consideration.

10. The military departments should provide adequate guidance so the contractors understand what tests should be included during the development phase. A procedure should be developed that assures

adequate planning prior to starting the testing, and provides a document that reflects an understanding of the agreement between the government and the contractor specifying the intent of the test. The criteria for failure and the procedural rules should be included.

11. The reliability test starts as early as possible in the acquisition process. Adequate funds to be made available so that most failures can be found and corrected during the engineering development phase. The levels of tolerance for time, environmental stress levels, including appropriate combined stress, and environmental cycle to be conducted during engineering development testing.

12. Establish a comprehensive reliability data base of previous analyses, caused failures, and reevaluate the current approach to allocating subsystems requirements.

13. Provide contractors with information they desire to design operational reliability into the systems. This will require more government involvement and also more coordination between the services.

RECOMMENDATIONS OF THE RESEARCHER

These additional recommendations are based on the personal experience of the researcher in the field of reliability testing.

Reliability growth be given more consideration during the Engineering Development Test, especially during the test-analyze-find and correct phase. This will include screening and replacing failure parts and the reliability caused by incorporation of appropriate design changes. This type of consideration prevents

the discovery of problems during the prototypes from being transferred to the production units.

To provide guidance to each of the military departments, a DOD reliability policy directive be established.

The contracting approach provide incentive for the contractor to meet or exceed the reliability requirement.

The attitude or belief that reliability can be achieved at the end of a development program and can be demonstrated should be changed. Reliability is a function of many things that happen after the design, most of these have been discussed in the study. Therefore, reliability should be viewed as a continuous process through operational deployment and the life of the program.

During the design phase, both parties should be qualified and willing to participate jointly and very candidly in identifying the operating environment and other factors that will affect reliability and life cycle cost.

Utilize a planned design update; it offers potential life cycle reduction through reliability and other improvements, increases functional capability, and extends the useful lifetime.

Findings and recommendations of previous studies conducted within the past three years be summarized and investigated for possible implementation.

The acquisition cycle for avionics equipment be shortened and separated from the long development cycle for the aircraft because of the changing technology of avionics equipment.

Avionic systems and subsystems be integrated and tested as an

integral system in the operational environment prior to completion of Engineering development tests.

Automatic test equipment and the associated software be given the same type of reliability consideration that we proposed for the hardware.

Reduce the overall test time by integrating the tests where possible. There should be more coordination and a team approach between government and industry. The development test and the operational test should be integrated to eliminate duplication of tests.

Establish a budget for engineer development testing during the time plans are being formulated for avionics systems and subsystems.

AREAS FOR FURTHER INVESTIGATION

1. As discussed in the conclusions and recommendations formed as a result of this study, a number of areas appear worthy of further investigation. One such area is: What is the approach for incorporating the logistic requirements, human factors reliability and operating conditions factors into the design?

2. Another one is the assessment of reliability as it relates to inherent MTBF and logistic support, Logistic MTBF. These are two separate areas, and it would be appropriate to investigate the specifics of each.

3. Investigate to determine what potential savings can be realized by shortening the development cycle of avionics equipment. A part of this investigation should be an assessment of the manager structure, i.e., the number of approvals required for decisions.

BIBLIOGRAPHY

Burkhard, A., et al. Environmental Effects on Reliability and Maintainability of Air Force Avionics Equipment. AFFDL, AFSC, Wright-Patterson AFB, Dayton, Ohio.

"Combined Environment Reliability Test Plan for the CN-1260/ASN-90(V) Inertial Measurement Unit," Report, prepared by PRAM Program Office in conjunction with the Aeronautical Systems Division Engineering Directorate and the Air Force Flight Dynamics Laboratory, 14 February 1977.

"DOD Weapons Systems Software Management Study, Appendix A, Findings and Recommendations of Previous Studies," APL-JHU, SR 75-3A. Maryland: Johns Hopkins University, June 1975.

Geise, J. and Holler, W. (ed.). Maintainability Engineering. Florida: Martin-Marietta Corporation, Duke University, 1965.

Gregson, J.; Blondin, R.; and Shinkle, R. Reliability Development Test for Avionics Equipment. Indianapolis: Naval Avionics Facility, Technical Evaluation Department, 31 May 1974.

Hirschberger, George, and Dantowitz, Allan. "Evaluation of Environmental Profiles for Reliability Demonstration," Final Technical Report, June 1973-January 1975, RADC-TR-75-242, prepared by Hughes Aircraft Company. Griffiss Air Force Base: Rome Air Development Center (RERT), September 1975.

Kern, G. A., and Baker, R. "Operational Influences on Reliability," Final Technical Report, April 1974-September 1976, RADC-TR-76-366, prepared by Hughes Aircraft Company. Griffiss Air Force Base: Rome Air Development Center (RERT), December 1976.

Mayer, Arnold H., Dr., and Prather, David K. "An Experimental Facility for Dynamic Combined Environments Reliability Testing of Airborne Equipment," Technical Report AFFDL-TR 76-108. Wright-Patterson Air Force Base: Air Force Flight Dynamics Laboratory, October 1976.

McIver, D., and others. "A Proposed Strategy for the Acquisition of Avionics Equipment," Report, prepared for US Air Force Project Rand, R-1499-PR. Santa Monica: Rand, December 1974.

Miller, D. Handbook of Research Design and Social Measurement. 2d ed. New York: David McKay Co., Inc., 1970.

"Operational Procedures for Optimized Reliability and Component Life Estimator (ORACLE)," Research and Development Technical Report

ECOM-4382. Fort Monmouth: US Army Electronics Command, December 1975.

Prather, David K., and Earls, David L. "A Flight Profile Combined Environments Reliability Test of the AN/APQ-146 Terrain Following Radar Systems," Final Report for Period 1 January 1975-September 1975, AFFDL-TR-76-20. Wright-Patterson Air Force Base: Air Force Flight Dynamics Laboratory, March 1976.

"Reliability in Aeronautical Avionics Equipment," A Report of the Air Force Technological Tradeoffs Panel to the Air Force Studies Board, National Research Council. Washington: National Academy of Sciences, 1975.

"Reliability Development Test for Avionics Equipment," Comments on AR 104 with Notice I, 31 May 1974. Indianapolis: Naval Avionics Facility, 1 October 1974.

Selby, J. D., and Miller, S. G. "Reliability Planning and Management (RPM)," A Paper presented at ASQC/SRE Seminar at Niagara Falls, NY, September 26, 1970. Utica: General Electric Company.

Swett, B., COL. Avionics Reliability Study - Phase II. HQ AFSC/XRX. Andrews AFB, MD: March 1974.

________, USAF. Office of the Director of Defense Research and Engineering. Letter to author, 31 August 1976.

Special Text. Research Development and Acquisition Management. Carlisle Barracks, PA: US Army War College, 14 March 1977.

Willoughby, W. "Reliability by Design, Not by Chance," Defense Management Journal, April 1976, pp. 12-18.

Reliability Tests: Exponential Distribution, Military Standard MIL-STD 781-B.

Reliability Development Tests, Military Standard, MIL-STD 2068(AS), 21 March 1977.

Reliability Test and Evaluation - Reliability Guides NAVORD OD 44622, Vol. 2. Washington: Published by the Direction of the Commander of the Naval Ordnance Systems Command, 29 October 1971.

US Department of the Army. Army Regulations 702-3: Army Materiel Reliability, Availability, and Maintainability (RAM). Washington: 15 November 1976.

________. Army Regulations 1000-1: Basic Policies for Systems Acquisition by the Department of the Army. Washington: 1 January 1975.

US Department of the Army. Army Regulations 1000-2: Operating Policies for Systems Acquisition by the Department of the Army. Washington: 4 January 1977.

US Department of Defense. Department of Defense Directive 5000.1: Major System Acquisitions. Washington: 18 January 1977.

________. Department of Defense Directive 5000.2: Major System Acquisition Process. Washington: 18 January 1977.

APPENDIX A

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APPENDIX B

AF REGULATION 80-5

RELIABILITY AND MAINTAINABILITY PROGRAMS FOR

SYSTEMS, SUBSYSTEMS, EQUIPMENT,

AND MUNITIONS

DEPARTMENT OF THE AIR FORCE
Headquarters US Air Force
Washington DC 20330

AF REGULATION 80-5

2 July 1973

Research and Development

RELIABILITY AND MAINTAINABILITY PROGRAMS FOR SYSTEMS, SUBSYSTEMS, EQUIPMENT, AND MUNITIONS

This regulation outlines the objective, basic concepts, and policy of the Air Force Reliability and Maintainability (R&M) Program for systems, subsystems, equipment, and munitions, and assigns responsibility for developing and managing them. These policies apply to both development and operational hardware; for more specific guidance on operational equipment, see AFR 400-46.

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SECTION A — TERMS, OBJECTIVES, AND BASIC CONCEPTS

1. Terms Explained:

a. **Exploratory and Advanced Development.** See AFR 80-1.

b. **Communications — Electronics Implementation Plan (CEIP).** See AFR 100-2.

c. **Development Concept Paper (DCP).** See AFR 800-2.

d. **Hardware Reliability.** The probability that a part, component, subassembly, assembly, subsystem, or system will perform for a specified interval under stated conditions with no malfunction or degradation that requires corrective maintenance actions. Hardware reliability may also be expressed in terms such as Mean Time Between Failure (MTBF) or Mean Time Between Maintenance

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Supersedes AFR 80-5, 13 December 1968. (For summary of revised, deleted or added material, see signature page.)

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Actions. (Time should be expressed as operating time unless otherwise specified.)

e. **Operational Reliability.** The probability that an operationally ready system will perform as required to accomplish its intended mission or function as planned.

f. **Maintainability.** A characteristic of design and installation expressed as the probability that an item will be restored to a specified condition within a given period of time when the maintenance is performed using prescribed procedures and resources. Hardware maintainability may also be expressed in such terms as Mean Time to Repair, Maintenance Man-hours per Flying Hour or Mean Down Time.

g. **Program Advocacy.** See AFR 800-2.

h. **Program Management Directive (PMD).** See AFR 800-2.

i. **Program Management Plan (PMP).** See AFR 800-2.

j. **Required Operational Capability (ROC).** See AFR 57-1.

k. **Source Selection Evaluation Board (SSEB).** See AFR 70-15.

l. **Single Thread Data System (STDS).** A combination of data systems which provide for commonality of data elements and the resultant capability to assess R&M performance of a system or item considering the total data base generated throughout its life cycle.

m. **System.** A composite of equipment, skills, and techniques capable of performing or supporting an operational role. A complete system includes related facilities, equipment, material, services, and personnel required for its operation so it can be considered a self-sufficient unit in its intended operational and support environment. (When the word "system" is used in this regulation, subsystem, equipment, munitions, and related items also apply.)

2. Program Objectives. The objectives of the Air Force R&M program are to contribute to the performance and cost effectiveness of Air Force hardware by developing:

a. Realistic R&M requirements;

b. Adequate provisions to demonstrate achievement of these requirements prior to production or modification decisions;

c. Management techniques to assure achievement of R&M requirements; and

d. An efficient basis for applying and tracking R&M achievements for use in both engineering and logistic decisions.

3. Basic Concepts:

a. Systems effectiveness and cost-effectiveness are prime requisites in providing Air Force systems for national security. Systems effectiveness is achieved through the unified efforts of systems engineering, logistics and management disciplines in obtaining the required performance requirements. Cost-effectiveness is achieved through the trade-off of acquisition and support costs to obtain desired system effectiveness at the lowest total cost of ownership.

b. Because reliability and maintainability are major factors in system effectiveness, in logistics support requirements, and in total cost, throughout each system's life cycle, they must be included in each study of system tradeoffs.

c. Reliability and maintainability (R&M) are important design and operational planning factors; their achievement in the development, production and operation of a system requires the use of realistic requirements. These requirements shall be imposed and enforced contractually by management during the development phase and follow-on phases of a weapon system.

SECTION B—AIR FORCE POLICY

4. R&M Parameters. R&M parameters shall be identified as system design requirements and used during each phase of the life cycle. Realistic and meaningful R&M characteristics and levels will be determined by cost effectiveness analysis, reflecting both system effectiveness and life cycle costs. The establishment of minimum acceptable R&M levels must be determined on the basis of realistic operational needs.

a. Each Air Force organization that participates in the requirements, development and

acquisition processes shall consult with operational and supporting commands in determining realistic R&M characteristics and objectives during the conceptual phase, using the results of studies, and prior experience. These characteristics and objectives shall be continually verified and progressively quantified throughout subsequent phases.

(1) Each activity that prepares a ROC will consider prior experience with similar equipment, operational need, discussions with AFSC and AFLC, and operational and support concepts, in developing realistic R&M design and support objectives. It is especially important in this process to describe the critical mission and support needs clearly enough that realistic R&M parameters can be derived from this description. These parameters can be addressed in qualitative or quantitative terms, depending upon the available experience. In any event, the ROC should describe the R&M or critical mission and support parameters clearly, since they serve as the baseline for future development and optimization efforts.

(2) Each program document (such as the PMD, CEIP, and PMP) shall include realistic R&M design and support objectives, numerical requirements, and mission requirements, as the status of the system or equipment definition allows. If these parameters cannot be included, the document shall provide planning guidance for the use of the implementing command in establishing these requirements.

(3) The documentation prepared for program advocacy during the conceptual phase shall present the potential R&M levels involved in each candidate system design and describe any special efforts or risks involved in achieving them in the development process.

b. **Planning Information.** The preliminary maintenance concept and constraints on the operation and maintenance of the system will be included in each planning document (study, Request for Proposal, etc.) in sufficient detail to permit realistic modeling and to guide the designer toward an effective design. Information to be included in the maintenance concept can be found in attachment 1 of AFR 66-14. Types of information required will vary with the phase of development.

c. **Operational and Support Activities.** These activities shall:

(1) Provide and update R&M planning information during the system's conceptual, validation, full scale development and production phases.

(2) Exercise positive controls to achieve, maintain and improve operational R&M throughout the life cycle of each system. Conduct, under AFR 66-30 and 400-46, programs to identify requirements and implement efforts to improve the R&M of operating equipment.

5. Contract Requirements. R&M program plans of potential contractors will be significant factors in source selection actions, especially as they impact system and cost effectiveness. The proposer's past efforts and achievement, his proposed objectives and programs, will be considered when sources are being selected. Contract incentives in terms of performance guarantees for reliability, maintainability, system effectiveness, or life cycle costs, will be used when the minimum acceptable requirements and demonstration plans are sufficiently defined to permit a clear measurement of contractor performance (DOD Incentive Contracting Guide, AFP 70-1-5). While most Air Force equipments are developed through contractual efforts, there is considerable work done in-house by the Air Force for which R&M programs could be appropriate. Consequently, this regulation applies equally to in-house programs, projects, tasks, or work units, as well as to contractual efforts.

a. When a developmental effort is not directly related to an advocacy program, or to the production of specific hardware:

(1) Contracts for research will be exempt from R&M requirements of this regulation.

(2) Contracts for exploratory development that do not involve hardware development, or for hardware that is to be a test item produced solely to demonstrate the feasibility of a concept, will be exempt from the numerical R&M requirements of this regulation.

(3) Contracts for Advanced Development of hardware shall:

(a) Include numerical hardware R&M design objectives.

(b) Require an analysis of all failures, to determine the failure mode and the probable cause, with feedback to design activities.

(c) Require an update of R&M predictions, based upon engineering analysis and data obtained from test programs.

(4) Contracts for prototyping shall not ordinarily require formal R&M programs, but shall follow the policies outlined in subparagraphs (2) and (3) above. However, if the prototyping effort is planned to lead directly into production, without a full scale development effort, the prototyping contract will establish numerical R&M requirements which must be demonstrated. In that case, applicable portions of this regulation and MIL STDs 785 and 470 will be followed.

b. When the developmental effort is directly related to program advocacy and obtaining approval of an acquisition program, each phase described below shall contain a requirement for contractor R&M programs extending through the subcontractor levels.

(1) During the conceptual phase, R&M characteristics and operational or support constraints shall be considered in trade-off studies and quantiative R&M objectives shall be established. These objectives may be modified in latter phases, but must be established during the conceptual phase.

(2) During the validation phase, quantitative R&M values shall be specified. These values may be specified as design objectives when preceding studies and operational constraints cannot adequately define minimum acceptable and technically achievable values. These values shall be refined and firm requirements established before full-scale development phase begins. Demonstration of these values is not mandatory during the validation phase; however, R&M predictions, analysis of R&M data from all testing, and determination of R&M deficiencies and necessary corrective action shall be performed, documented and carried forward to the full-scale development phase for update and corrective action. A reliability evaluation test (that is, a test to determine reliability deficiencies rather than to demonstrate achievement of specified values) may be required and be advantageous to Air Force in the validation phase.

(3) In the full-scale development phase, the contract documentation shall include comprehensive R&M programs in accordance with MIL-STDs 785 and 470. The RFP for this contract may contain a range of acceptable R&M values, so that the potential contractors may propose on various levels within that range. The contract award may then be made at the level most favorable to the Air Force provided that the source selection criteria define the basis for the award. In any event, the final contract must contain numerical R&M requirements which must be demonstrated before production begins.

(4) In the production phase, the contract for production items (including reprocurement of equipment and components whose R&M have been demonstrated and found adequate) shall include, as a minimum, the same R&M values for the production equipment and shall require periodic verification of reliability during production runs. Successful R&M demonstration will be a condition of acceptance. If the R&M parameters of the existing equipment have been found inadequate, the procurement data will be revised to reflect the required improvement. Major R&M deficiencies shall require a special program for improvement and demonstration.

(5) In the production phase, the procurement of an existing item which did not have prior R&M requirements imposed but which has demonstrated satisfactory operational R&M characteristics, need not contain provisions for specific requirements; however, the contract will contain provisions to assure that demonstrated R&M characteristics are not degraded. R&M provisions in these cases must be approved by the R&M focal point of the organization involved. The supporting rationale will be documented in the contract file.

c. Other R&M contractual requirements include the following:

(1) R&M demonstrations shall be conducted as an integral part of the overall test program (AFR 80-14) in an operational or simulated operational environment using the test procedures prescribed in MIL-STDs 781 and 471A. When the procuring, operating and supporting agencies determine jointly that these test methods are inappropriate, alternate tests shall be specified by the Air Force. In any event, the procuring activity must assure that the specified tests will produce adequate confidence that minimum acceptable levels of

R&M have been achieved. The demonstrations must be completed before the end of the full-scale development phase and the results made available for use in making a production decision.

(2) When, due to very high MTBF requirements, meaningful reliability demonstrations cannot be performed cost effectively, design qualification may be achieved by an analysis of the data from functional, environmental, screening and low-confidence reliability tests of the item. Similarly, if due to limited production quantities, meaningful production acceptance tests are not practical, production contracts shall include reliability, warranty or correction of deficiency provisions covering an appropriate period of the operational phase. The rationale for the course of action taken will be documented in the contract file.

(3) For a less complex development effort (that is, one which is defined as an individual equipment or minor subsystem development, involving a limited amount of new and unproved designs and characterized by no conceptual or validation phases preceding development), a less extensive program may be used. In this situation, although numerical R&M requirements and demonstrations are required, selected tasks from MIL-STDs 785 and 470 may be used without invoking the complete standards or requiring R&M program plans.

(4) When procurement is based on vendor technical and engineering data alone, this data must provide assurance that the R&M performance parameters are adequate for the intended application and are controlled for uniformity. Generally, when an off-the-shelf aircraft or item of aeronautical equipment is being procured that has been certified for airworthiness under the Federal Air Regulations, airworthiness certification test records and R&M experience during civil operations will be assessed as a basis for procurement. The policies outlined in paragraph 5b will apply to complex commercial or off-the-shelf equipment, whose functions affect safety or mission accomplishment as follows:

(a) To equipment which was not certified to operate under conditions as rigorous as are envisioned for its USAF use; or

(b) To uncertified equipment when vendor technical data is inadequate as determined by Air Force engineering personnel.

(5) The contract for any system (or part of a system) which will be inaccessible during its operational life, or which employs a "discard at failure" concept, or which is being produced by a manufacturer other than the designer, shall not require a maintainability program, numerical maintainability requirements, or a maintainability demonstration.

(6) Each contract schedule shall allow sufficient time for satisfactory demonstration of the minimum acceptable R&M parameters of hardware involved.

(7) Each contract for system development and acquisition will include the minimum essential data requirements upon which R&M control, visibility and management decisions may be based. The standard data items developed for these purposes are in the DOD authorized Data List (DOD-ADL).

(8) For a major weapon system, the procuring activity, with the aid of the appropriate contract management agencies (such as the Air Force Plant Representative Office), will maintain surveillance over the contractor's R&M programs. For other than a major system, the contract administration activity will maintain surveillance over the contractor's R&M programs, but will provide feedback to the procuring activity on contractor performance. However, in the surveillance of any contractor R&M program, the procuring activity may obtain support from any Air Force activity that has the pertinent technical capability, or from a technically qualified contractor (if no conflict of interest is involved).

(9) During the full-scale development phase, an optimum repair level analysis will be performed in accordance with the joint procedures of AFLC and AFSC. This analysis may be performed earlier — as a preliminary study — but, if so, it will be updated during the full-scale development phase.

(10) The total cost for the delivery of a ready and operationally effective system will include the cost of achieving R&M. Each change in the original scope of the R&M effort must be validated by a system cost-effectiveness analysis that encompasses the total life cycle of the system.

(11) The extent to which this regulation applies to quick reaction capability (QRC) procurements will be determined under AFR 57-5. When program schedule constraints preclude use of a complete R&M program, one of reduced degree should be incorporated such as design review, burn-in, R&M analysis and prediction. If R&M requirements are included in a QRC contract, the policies outlined in this regulation will be used for guidance.

6. Human Performance Reliability Factors:

a. During the design, development and test process, R&M program monitoring activities must coordinate closely with personnel subsystem activities (AFR 80-46). When appropriate, the policies outlined in AFM 35-99 will be applied.

b. The human performance reliability analysis, developed by implementing AFR 80-46, is an integral part of system R&M. It includes systematic identification and recording of critical human initiated effects in relationship to system performance.

7. Test and Field Data System. Air Force test and field data systems must be compatible and be capable of evaluating and verifying system performance throughout its life cycle, including in-depth assessment of R&M parameters. Each data system must provide for feedback of R&M experience to influence the design of new systems and redesign of existing ones where necessary.

8. Engineering Changes. When a system does not meet test, operation or technical performance requirements because of R&M deficiencies, engineering changes will be considered. Approval of retrofit changes will be accomplished as outlined in AFR 57-4.

9. Policy Waivers. Except as listed below, any request for a waiver of the policy outlined here will be processed through command channels to HQ USAF/LGY for staffing and final decision. Also, HQ USAF approval must be obtained before scheduling any contract program that provides for a production release prior to the satisfactory completion of R&M testing and analysis. Any of the waivers or deviations listed below require the approval of both the headquarters of the major command accomplishing the procurement, and the using command. This authority cannot be redelegated.

a. The use of a nonstandard MIL-STD test or demonstration, when a *standard* test is available, or acceptance by similarity of prior tests accomplished.

b. The acceptance of test or demonstration results that are less than required by contract.

SECTION C—RESPONSIBILITIES FOR ESTABLISHING, MONITORING AND IMPLEMENTING R&M PROGRAMS.

10. Responsibilities of HQ USAF. This headquarters will:

a. Formulate, establish, and maintain policies on R&M programs for all systems and associated material in design, development, production, and operational service.

b. In each PMD include the R&M requirements or objectives (or an adequate description of each mission-critical parameter) so that meaningful R&M parameters can be derived. Unless expressly waived or modified in the PMD, the policies outlined here shall apply.

c. Establish an Air Staff R&M program OPR and an R&M focal point within the appropriate Air Staff elements, to monitor, review, evaluate and guide the Air Force R&M program.

d. Direct and support the development and establishment of an Air Force-wide R&M educational and training program to increase the capability of professional, technical, and management personnel and to provide for an effective exchange of technical information.

e. Establish and maintain a program element (AFR 27-9) for general R&M technological improvement, engineering application, and control.

f. Evaluate major command requests for a waiver of R&M policy on a specific procurement or development effort, and advise the requesting command of the decision reached.

11. Responsibilities of the Air Force Systems Command. This command will:

a. Establish and monitor a command R&M program.

b. Establish an R&M focal point within the appropriate staff element of HQ AFSC, and an office of primary responsibility (OPR) at other levels of command organizations.

c. Designate an R&M engineer for each system program or project, or assign a centrally located R&M engineer to each program to assist the director or manager in accomplishing the following R&M responsibilities:

(1) Provide R&M inputs into program documentation and the contractual documents, according to the policies outlined here.

(2) Be responsible to the system program director or project manager for the attainment of the program's R&M requirements.

d. Support the operating commands in establishing R&M objectives or in identifying critical mission needs so that R&M parameters can be derived for inclusion in ROCs.

e. Conduct research and development programs to improve techniques, dealing with specifying, predicting, demonstrating and improving R&M for developing human factors engineering principles and design criteria which will support R&M programs.

f. Incorporate numerical R&M requirements, and procedures for demonstrating their achievement, in the pertinent specifications, exhibits, product descriptions, work statements, and contractual clauses to be referred to, or included in, system contracts. Also assure that reprocurement data include the numerical R&M requirements for use in replenishing a system's logistic support.

g. Work with AFLC and the operating commands to assure that the contractor's R&M program proposal is evaluated as an important part of systems source selection action.

h. Assure the adequacy of each contractual R&M acceptance test and demonstration. When feasible, use an integrated test plan to minimize the cost of testing.

i. Implement a data system to measure and evaluate R&M during test programs. In conjunction with AFLC, take necessary action to implement a "single thread" data system.

j. Help ATC and AU develop formal Air Force R&M education and training programs and courses. Conduct informal R&M training as required to clarify issues and resolve misunderstandings.

k. Coordinate with AFLC and the using commands to assure that the content and presentation techniques of maintenance and operating instructions are compatible with the maintenance concept and that they contribute proportionately to the maintainability of the overall system.

l. Include development reports at least quarterly in each program acquisition review (PAR) on the status of system R&M, until Air Force engineering responsibility is transferred to AFLC.

m. Implement a modification program to enhance system R&M for operational hardware that has not been transferred to AFLC for engineering responsibility.

n. Transfer to AFLC and the operating commands the R&M data (including functional reliability models) obtained and verified during development, design, test and evaluation.

12. Responsibilities of the Air Force Logistics Command:

a. Establish and monitor command R&M programs to effectively accomplish command responsibilities.

b. Establish R&M focal points within the appropriate staff element of HQ AFLC and OPRs at other command organizations as necessary.

c. Help Air University and Air Training Command develop Air Force R&M education and training programs and courses. Conduct command education and training programs and courses.

d. Coordinate R&M requirements in AFSC developed specifications and Statements of Work for equipment destined to become operational or having an operational application.

e. Establish or update R&M requirements for items procured by AFLC. Where engineering responsibility has not been transferred coordinate such actions with AFSC.

f. Participate in source selection evaluation board (SSEB) action, and collaborate with AFSC and the operating command, to determine R&M requirements to be specified in the

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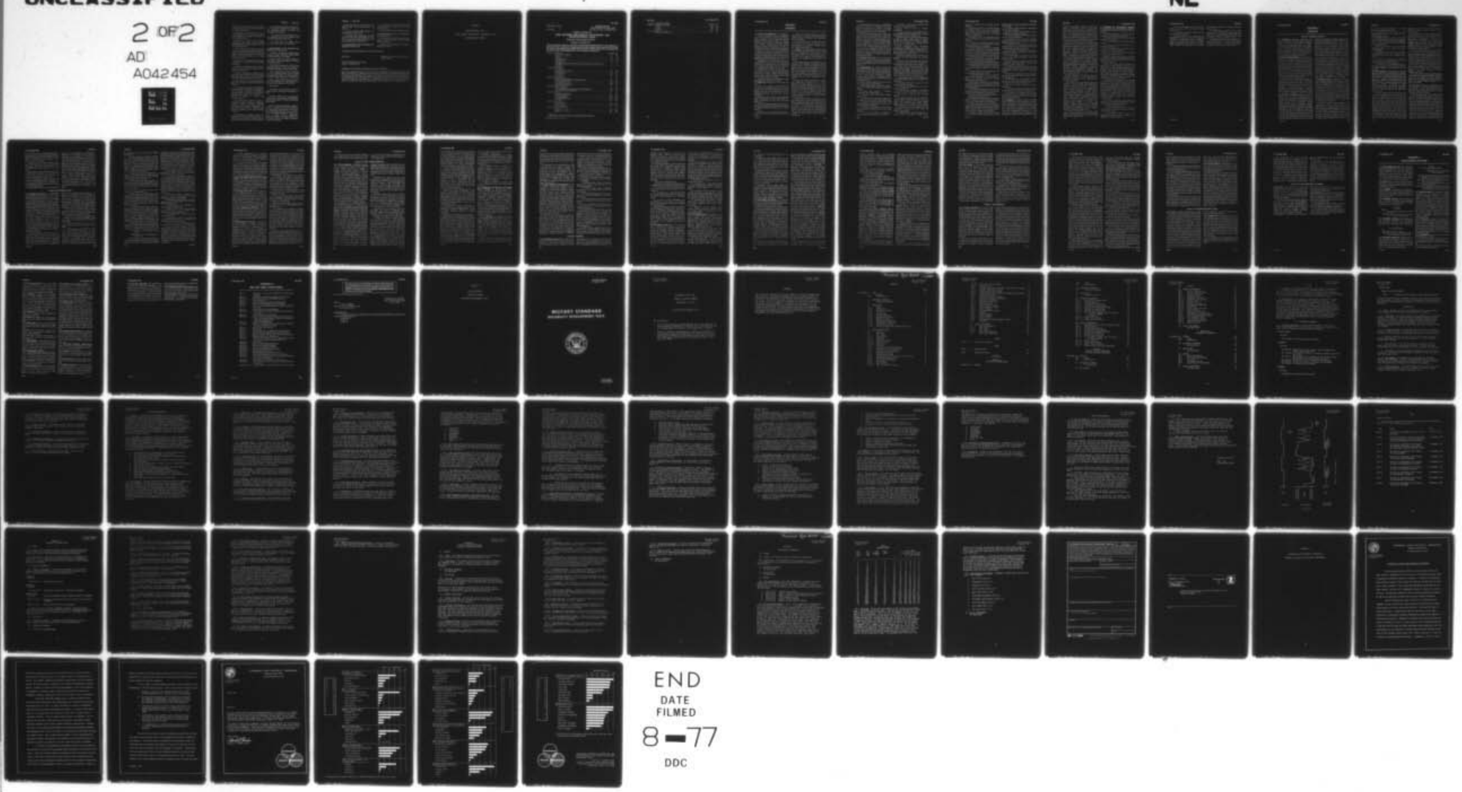

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RFP and the work statement for each system that is destined to become operational, or have an operational application.

g. Participate in the design review of new and modified systems and equipment. Recommend alterations or changes as necessary to improve R&M of items.

h. With AFSC and the using commands, participate in tests (AFR 80–14) to evaluate achieved R&M and support provisions for new and modified systems.

i. With AFSC, identify, develop and keep current, a management information system to reflect the degree of achieved R&M, using operational and maintenance data. In concert with AFSC, strive for achievement of a "single thread" data system.

j. Furnish the appropriate R&M management products to the AFSC and the operating commands.

k. Establish an R&M performance feedback system to support the effective design and production of new systems.

l. Conduct a maintenance manager review discussed in AFR 66–12 and adjust inspection and replacement intervals for time change items when justified by R&M considerations.

m. With acceptance of engineering responsibility for a system, AFLC will accomplish the following:

(1) Incorporate or revised, as appropriate, numerical R&M requirements and demonstration provisions in applicable specifications, exhibits, product descriptions, work statement, and contractual clauses to be referred to, or included in, contracts for systems and associated material.

(2) Perform R&M functions related to engineering change proposals, modification programs, inspection procedures, advanced procurement data programs, qualification and first article testing, waivers to engineering and technical requirements, and system interface problems.

(3) Determine the specific reason for unsatisfactory hardware R&M and initiate cost effective actions to increase the R&M of operational systems (AFRs 57–4, 66–30 and 400–46).

(4) Accomplish prototype testing and side-by-side operational comparison of modified versus unmodified hardware (subsystem and equipment) as necessary to:

(a) Verify the forecasted effectiveness of the modification in the areas of reliability, maintainability and logistic support cost.

(b) Verify that new failure modes associated with safety are not introduced.

13. Responsibilities of the Operating Commands. These commands will:

a. Establish a headquarters R&M program manager, or panel, to develop command policy for implementing Air Force policy.

b. Include in ROCs and CEIPs submitted to HQ USAF, planning information as discussed in paragraph 4 above.

c. Help AFSC prepare and review system planning documents to ensure the adequacy of operational and logistic support requirements.

e. When conducting an initial operational test and evaluation (OT&E) of new systems and equipment (AFR 80–14), verify with AFSC and AFLC, R&M achievements accomplished.

f. Refine system R&M assessments during follow-on operational test and evaluation of new systems and equipment (AFR 80–14).

g. Help AFLC:

(1) Conduct formal periodic reviews of R&M programs on appropriate operational systems.

(2) Collect R&M data on operationally deployed systems by assigning and administering necessary resources to collect and transmit required data.

h. Insure that operational R&M of deployed systems is maintained at the level specified in the system and CI specifications; report hardware R&M deficiencies that have an impact on the operational capability of weapons systems or require excessive maintenance resources (manhours and costs); participate in a program to increase the R&M of operational systems (AFR 400–46).

i. Help ATC and AU develop Air Force R&M education and training programs and courses.

j. Conduct command R&M education and training programs and courses.

k. Coordinate R&M requirements in AFSC and AFLC developed specifications and statements of work for equipment destined to support command mission requirements.

14. Responsibilities of the Air Training Command. This command will:

a. In coordination with other involved commands, develop and conduct Air Force R&M training courses.

b. Evaluate effectiveness of training courses.

15. Responsibilities of the Air University. The University will:

a. In coordination with other involved commands, develop and conduct Air Force R&M education programs.

b. Conduct follow-up evaluation of education program effectiveness.

BY ORDER OF THE SECRETARY OF THE AIR FORCE

OFFICIAL

JOHN D. RYAN, JR, General, USAF
Chief of Staff

JACK R. BENSON, Colonel, USAF
Director of Administration

SUMMARY OF REVISED, DELETED OR ADDED MATERIAL

This revision includes the phases of a system life cycle and program documentation defined in AFR 800–2. It also clarifies the distinction between hardware reliability and operational reliability (para 1); provides added emphasis to the need for cost effectiveness analysis (para 3); consolidates in one paragraph all of the information about contractual documentation and requirements (para 5); deletes the requirement to implement a maintainability program when not appropriate (para 5c(5)); and expands and clarifies the conditions under which a policy waiver is required (para 9).

APPENDIX C

ARMY REGULATION 702-3

ARMY MATERIEL RELIABILITY, AVAILABILITY, AND MAINTAINABILITY (RAM)

ARMY REGULATION
No. 702-3

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, DC, *15 November 1976*

PRODUCT ASSURANCE

ARMY MATERIEL RELIABILITY, AVAILABILITY, AND MAINTAINABILITY (RAM)

Requirement Control Symbol CSCRD-73

Effective 1 January 1977

This is a complete revision of AR 702-3. Local limited supplementation of this regulation is permitted, but is not required. If supplements are issued, major Army commands will furnish one copy of each supplement to HQDA (DAMA-PPM), WASH DC 20310; other commands will furnish one copy of each supplement to the next higher headquarters.

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***This regulation supersedes AR 702-3, 22 March 1973, including all changes.**

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CHAPTER 1
GENERAL

1-1. Purpose and applicability. This regulation—

a. Sets forth objectives, concepts, responsibilities, and general policies for Army materiel reliability, availability, and maintainability (RAM) programs. These programs apply to materiel systems,[1] test measurement and diagnostic equipment (TMDE), training devices and facilities developed, produced, maintained, procured, or modified for Army use and for which quantitative requirements for RAM are normally applicable.

b. Includes coverage of components of systems, TMDE, training devices, and facilities to the extent that they are integral or separate functional components of military systems (e.g., generators, facilities equipment, missile elevators, etc.)

c. Establishes the manner by which the RAM characteristics are to be stated in requirements documents, to be designed into systems, to be used in the design of the support systems, and to be assessed throughout the life cycle of materiel.

d. Includes the treatment of RAM for non-development items (i.e., commercial Nondevelopmental Items—CNDI, Military Adapted Commercial Items—MACI, and equipment developed by other military services or allies).

e. Applies to the Reserve Components when dealing with the RAM data collection.

1-2. Objectives. The objectives of this regulation are to—

a. Insure that materiel systems provided to the Army are operationally ready for use when needed, will successfully perform their assigned functions, and can be economically operated and maintained within the scope of logistics concepts and policies.

b. Formulate, define, and insure promulgation of RAM requirements for systems developed, procured, or improved to meet valid user needs (AR 70-15).

c. Assure that the RAM program contributes to reducing the overall life cycle cost, while increasing the overall performance effectiveness of Army systems.

d. Assure that RAM requirements or RAM characteristics are properly demonstrated and/or assessed during development and operational test and evaluation.

e. Assure that the results of RAM demonstrations and/or assessments are portrayed in a suitable form for the decision making process (i.e., IPR/ASARC/DSARC).

1-3. Concept. *a.* The RAM program for an item is pursued within the framework of DA Pam 11-25 and is an integral part of the general system development process by which required levels of effectiveness are achieved and maintained at minimum cost throughout the entire life of the system.

b. The effectiveness of a system depends on its capability and availability to perform a specified military mission. This overall effectiveness depends on the materiel design capabilities, including RAM, and the concept of employment and support. Consequently, the effectiveness of a system will vary according to its reliability and maintainability and the effectiveness of support under multiple system uses in an operational environment.

c. Appropriate RAM characteristics or higher order effectiveness parameters (e.g., systems effectiveness, annual support costs, or probability of single shot kill) must be properly and adequately quantified in requirements documents, included in contract specifications, and measured during tests, in order to: Influence design of the system, permit an accurate determination of test requirements and test results, and permit logistic support planning.

d. Achievement of RAM requirements will be demonstrated and assessed in conjunction with both development testing (DT) and operational testing (OT). RAM characteristics will be assessed and judged as to their adequacy during the development process by Army Systems Acquisition Review Council/Defense Systems Acquisition Review Council, and In-Process-Review (ASARC/DSARC, and IPR) (AR 15-14 and AR 70-1) membership.

[1] The term system is used throughout this regulation to indicate either an item or system (group of items) of materiel.

e. Determining RAM requirements, establishing contractual RAM values, designing RAM tests, assessing test results, and decisions concerning RAM acceptability are separate events which require separate and distinct considerations.

f. Notwithstanding the provisions of this regulation, all users of this regulation (combat developers, materiel developers, testers, and evaluators) are encouraged to exhibit maximum flexibility in developing and executing RAM Programs or any subelement to Army materiel. RAM Programs shall be tailored to the individual needs of each system. RAM programs are expected to vary in scope and complexity between major and nonmajor systems. Materiel developers should pursue both hardware and program alternatives which are cost-effective in achieving reliable and maintainable materiel.

1-4. Explanation of terms. Terms used in this regulation are explained herein and in Appendix A. Also, see definitions in AR 310-25, MIL-STD-721B, and MIL-STD-781B, and abbreviations in AR 310-50.

1-5. Responsibilities. The AR 10 series describes responsibilities of the Army Staff and of the major Army commands. The AR 70 series, AR 702 series, and AR 750 series describe specific responsibilities in Army research and development, product assurance, and maintenance. Additional specific responsibilities for carrying out the RAM program are described below.

a. Deputy Chief of Staff for Research, Development, and Acquisition (DCSRDA).

(1) Has primary Army general staff responsibility for the overall RAM program pertaining to materiel.

(2) Issues Army policies on reliability, availability, and maintainabilty.

(3) Supervises the major RAM program elements to—

(*a*) Insure that valid RAM requirements are addressed in the requirements documentation.

(*b*) Insure that Development Plans (AR 70-27) provide for achievement, assessment, and testing (AR 70-10) of RAM.

(*c*) Promote development, improvement, and application of RAM technology and design practices.

(*d*) Insure that RAM is evaluated in product improvement programs (AR 70-15).

(4) Monitors consideration of RAM during the DA decision making process.

b. Deputy Chief of Staff for Logistics (DCSLOG).

(1) Insures continued compatibility between the Integrated Logistic Support (ILS) program (AR 700-127) and the RAM program.

(2) Provides policy guidance concerning the provision of logistic support input to combat development and materiel development agencies for use in developing and validating RAM characteristics on new materiel.

(3) In coordination with ODCSOPS, ODCSRDA, and OTEA, has approval authority for deviation from complete maintenance test support packages for DT/OT II and III for major and category 1 nonmajor systems.

(4) Insures continued data collection and assessment of RAM performance for deployed systems.

(5) Assists in DA Staff evaluation of changes to operational materiel RAM characteristics resulting from product improvement programs.

c. Deputy Chief of Staff for Personnel (DCSPER), Deputy Chief of Staff for Plans and Operations (DCSOPS), Assistant Chief of Staff for Intelligence (ACSI), Chief of Engineers (COE) and the Surgeon General. Implement the policies set forth in their respective areas of interest.

d. Commanding General, US Army Operational Test and Evaluation Agency. For assigned items of materiel——

(1) Provides RAM OT portion of CTP, reviews and concurs in CTP's.

(2) Conducts operational tests and evaluations to assess RAM.

(3) Reviews and comments or coordinates on documents pertinent to RAM aspects of OT.

e. All materiel developing and procuring agencies.

(1) Determine jointly with the combat developer realistic RAM characteristics consistent with system operational and support requirements, current state-of-the-art, Army doctrine, organization and force structure, and the COEA.

(2) Validate the technical feasibility of RAM requirements proposed for items under the agency's development.

(3) Establish and maintain integrated controls to insure achievement of RAM require-

ments and execution of the policies of this regulation.

(4) Assess critical elements of RAM throughout the life cycle to detect causes or trends which may degrade system performance, operational readiness, or increase life cycle costs, and propose or take corrective action.

(5) Coordinate with the appropriate major Army commands for on-site monitoring of tactical materiel.

(6) Insure that a RAM data base is maintained (consistent with standard data systems) for materiel under their responsibility.

(7) Have approval authority for deviation from complete maintenance test support packages for DT and OT conducted on category 2, 3, and 4 systems; following coordination with members of the inprocess review (IPR). (See AR 700-127.)

f. Commanding General, US Army Materiel Development and Readiness Command. In addition to the responsibilities in paragraph 1-5*e*:

(1) Maintains a central activity for developing and improving RAM program methodologies by—

(*a*) Disseminating information concerning new RAM techniques applicable to Army programs.

(*b*) Identifying related technology gaps and recommending supporting research.

(*c*) Maintaining effective contact with elements of other government agencies, private industry, and universities on current technical progress in the state-of-the-art.

(2) Determines requirements, in coordination with other activities, for developing and carrying out Army reliability and maintainability education and training programs.

(3) Determines requirements, in coordination with other activities, for publishing and maintaining Army RAM handbooks and pamphlets.

(4) Executes staff proponency for AR 702-3.

g. All combat developing activites.

(1) Establish and maintain controls to insure effective coordination of RAM program functions and execution of the policies of this regulation.

(2) Determine jointly with the materiel developer realistic RAM characteristics consistent with system operational and support requirements, current state-of-the-art, Army doctrine, organization and force structure, and the COEA.

(3) Monitor materiel development to ascertain the degree to which the system has met the RAM requirements as demonstrated during appropriate testing.

(4) Monitor RAM performance throughout the life cycle of materiel.

(5) Are responsible for the logistic system certification as it impacts on RAM.

(6) *Are responsible for the training certification* as it impacts on RAM.

h. Commanding General, US Army Training and Doctrine Command. In addition to responsibilities in paragraph 1-5*g*:

(1) Maintains a central activity for the proper statement and content of RAM characteristics in materiel requirements documentation.

(2) Keeps abreast of current progress on state-of-the-art in RAM methodology as applied to combat developments.

(3) Conducts OT on assigned items of materiel to assess RAM and provides RAM OT portion of CTP.

i. Logistic (Readiness) agencies having national maintenance points (AR 750-1). Establish and *maintain controls to insure that*—

(1) Maintenance and logistic support concept and planning information is coordinated with the development activity responsible for equipment design.

(2) Planning for maintenance and other logistic support is compatible with specified RAM design requirements.

(3) Reliability and maintainability characteristics are maintained or improved during product improvement of materiel (AR 70-15).

j. US Army Logistics Evaluation Agency (USALEA).

(1) Provides surveillance of logistics support implications of proposed new items of materiel.

(2) Evaluates all developmental and nondevelopmental items for logistics supportability aspects of RAM in performance of its mission as the Logistician (AR 70-1).

1-6. Coordination. *a. Logistics.* Operational RAM can be significantly altered by changes in operational, environmental, or logistical support concepts. Organizations concerned with the RAM of a system and its components must maintain close coordination throughout the system's life cycle with organizations responsible for the operation and logistic support of materiel. This coordination should assure that RAM charac-

teristics are mutually compatible with logistic concepts. Maintenance concepts, repair parts provisioning, and allocation of maintenance resources must support the system readiness requirement. The RAM program must interface with logistic support planning and execution to insure that each complement one another and enhance the achievement of an affordable and supportable system that performs its intended function.

b. Personnel and training functions. Operational RAM characteristics are interrelated with human performance requirements and the development and use of trained personnel. Throughout the life cycle, coordinated planning among using, developing, logistics, personnel, and training agencies is required to assure compatibility between quantitative and qualitative personnel resources and materiel readiness requirements.

c. Defense Standardization Program (DODD 4120.3). Developing and procuring agencies should participate in the Defense Standardization Program through the preparation and use of applicable military specifications, standards, hand-books, and standardization studies in order to enhance interchangeability, reliability, and maintainability of military equipment and supplies. (See AR 700-47.)

d. Related regulations. Regulations which give additional information on the duties and responsibilities delineated in this regulation are listed in appendix B.

e. Test measurement and diagnostic equipment (TMDE). Use of TMDE and Built-In-Test Equipment (BITE) for hardware systems diagnosis or prognosis will be given consideration during design and development. TMDE requirements, except COMSEC materiel, will be coordinated with Commander, US Army Maintenance Management Center, Lexington-Bluegrass Army Depot, ATTN: DRXMD-T, (TMDE Product Management Office), Lexington, KY 40507, to insure maximum use is made of items developed and available to the Army, (AR 750-43). TMDE requirements for COMSEC materiel will be coordinated with Commander, US Army Communications Security Logistics Agency, Fort Huachuca, AZ 85613.

f. Support documentation and analysis. Procedures will be established to insure that RAM data are compatible with logistic support analysis requirements (AR 700-127).

1-7. Reliability and Maintainability Summary Report, Requirement Control Symbol: CSCRD-73.

a. Applicability. Reports will be prepared by the following:

(1) Commanding General, US Army Materiel Development and Readiness Command.

(2) Commanding General, US Army Training and Doctrine Command.

(3) Commanding General, US Army Security Agency.

(4) Commanding General, US Army Communications Command.

(5) Commanding General, US Army Operational Test and Evaluation Agency.

b. Frequency. Report will be submitted annually, as of the end of each fiscal year.

c. Submission. Five copies of each report will be submitted to HQDA (DAMA-PPM-T) Washington, DC 20310, NLT 30 days after the end of each reporting period.

d. General. This report will be prepared in a narrative letter form. Inclosures may be used. This report not only provides information as to program status but will also identify program, hardware, methodology, and software improvements made by one Army command or agency, which may be applicable to others. Each reporting activity will submit information covering only those subjects pertinent to its efforts.

(1) *Hardware improvement section.* Selected examples of hardware improvements during the equipment life cycle stages of development, production, and operational use will be given. The format should identify the item of hardware; the before and after RAM values for completed improvements; the area of improvement; and related benefits of the improvement, such as increased availability, estimated 5-year cost avoidance, decreased logistical burden, and related performance payoffs.

(2) *Program improvement section.* Summaries will be given on recently initiated RAM program improvements, including the following:

(*a*) RAM training courses.

(*b*) Improvements in timeliness and effectiveness of failure reporting, and analysis of critical and corrective actions.

(*c*) Strengthened policies, procedures, and management controls having an impact on the effectiveness of the RAM program.

(*d*) New techniques and procedures for prediction, design, and assessment of RAM characteristics.

(*e*) Significant activities which have advanced RAM achievement.

(3) *Report abstracts section.* Abstracts will be provided for reports on research, development, production, or maintenance projects specifically related to materiel RAM; physics of failure; safety; test techniques; and diagnostic test equipment (in-house or contracted). The abstracts will normally be limited to one page. Inclosures may be used.

(4) *Methodological summary section.* Summaries will be provided for unique and new applications of methodological approaches for assessment of RAM. Limitations or weaknesses in existing methodology will be identified.

(5) *Recommendations section.* Recommendations should be made as to changes needed in the Army RAM program to improve the capability of achieving or retaining desirable RAM levels.

CHAPTER 2

POLICIES

Section I. GENERAL POLICIES

2-1. Management. Planning, programing, and resource allocation will be provided throughout the life cycle of each system to achieve the RAM hardware and program objectives and requirements. The impact of RAM on mission accomplishment and logistic support will be considered. RAM characteristics will be identified among the principal performance characteristics of the system and will be reviewed by management and assessed throughout all life cycle phases.

2-2. Life Cycle RAM Program. *a. Conceptual phase.* During the feasibility studies and component development, the RAM potential of the item and its components will be examined. RAM evaluations will be conducted to assist in selecting proper technical approaches and to identify high technical risk. This information will also be used in the trade-off and cost effectiveness studies and to assist in final concept selection. RAM data collected from previous items, as well as data generated during research and feasibility studies, will be used and carried forth into the subsequent phases.

b. Validation phase. RAM efforts during the validation phase will be structured towards developing RAM requirements which are credible, realistic, attainable, meet an operational need and contribute to minimizing life cycle costs. Consequently, the relative importance of various RAM parameters for the item will be established during this phase along with the impact of RAM on operational performance and on logistics supportability. Quantitative RAM goals or objectives (i.e., not firm requirements) may be established and used during the validation phase. Based on this, the degree to which RAM may be traded off will also be ascertained. Typical RAM activities such as predictions, analyses, data collection and assessment and failure analysis/corrective action will be executed. Firm RAM requirements will be established during this phase for inclusion in the ROC, LR, or TDR.

c. Full scale development phase. RAM program activities and management controls will be executed and exercised in order to insure that materiel is developed which fully conforms with the stated requirements. Quantitative RAM requirements in a Required Operational Capability (ROC), Training Device Requirement (TDR), or Letter Requirement (LR) will be included, and expanded as necessary, in the Development Plan. RAM requirements, programs, testing management controls, and data systems will be included in solicitations and contracts. RAM interfaces with other engineering functions will be established to insure compatibility and smooth production transitions.

d. Production and deployment. RAM efforts during production will be oriented towards insuring the minimum degradation of RAM during the transition to and continuation of production and correction of deficiencies found during testing. As a part of the System Assessment and RAM Improvement of Selected Equipment (RISE) activities, RAM data will be collected and analyzed throughout production and deployment to assure that RAM levels are maintained, corrective actions are initiated, and RAM product improvement candidates are identified.

2-3. Reliability growth. *a.* Reliability of materiel should increase during the development process. Such "reliability growth" is a function of the maturity of design and the application of engineering and test resources. The Army objective of delivering systems that have good reliability characteristics cannot be accomplished simply through testing systems at the end of the development cycle. Decision bodies must be provided visibility on how reliability is progressing throughout the program so that cost effective action and corrections can be made prior to the production decision on the item/system.

b. Materiel developers will use reliability growth management to insure visibility of system reliability progress during the development cycle. This reliability growth management will consider not only the growth to the specified value but will also aid in making a determination of the time and resources necessary to reach this requirement. Further, intermediate reliability criteria will be established from the growth curve for the system

to assist the materiel developer in assessing progress toward the specified value.

c. Materiel developers will develop and use reliability growth curves on all major and designated nonmajor systems.

d. Reliability growth as used in the Army Materiel Acquisition Decision Process is a management tool rather than a technical tool. Reliability growth management should provide the following to the decision process:

(1) Aid in allocating resources to achieve reliability requirements on schedule and within cost constraints.

(2) Focus attention on failure to meet intermediate criteria in order that corrective actions can be taken to meet the final reliability requirement.

(3) Place into perspective the relationship of achievement of required RAM to the rest of the development and testing program.

(4) Indicate early in the development cycle, preferably by DT/OT I, but no later than DT/OT II, the achievability of the specified value for reliability.

2-4. Data collection. *a.* RAM data are required during all phases of the materiel life cycle. During development and operational testing, RAM data are required to evaluate the materiel system and plan for its support. During production and deployment, RAM data are required to evaluate the performance of materiel systems and major subsystems, provide a foundation for future development programs and provide for logistic support information. Data will be collected in consonance with AR 700-127 and MIL-STD-1388-1 and -2.

b. An effective and economical RAM data system will be established by each activity having a materiel development or procurement mission. All data systems will provide for organized and timely collection, analysis, use (immediate and long range), systematic storage, and disposition of the data. The data system will include all data needed to permit assessment of the RAM characteristics of an item and its components. Data systems must be based on plans (included in development plans) which define exactly what data elements are to be collected and the controls to be exercised to insure that all data are appropriately disseminated, analyzed, and used expeditiously. The data system will be established and maintained to meet the needs of its users (e.g., combat developers, materiel developers, testers, and evaluators).

c. All RAM data and incident reports from DT and OT will be provided and exchanged among the combat developer, materiel developer, operational tester, and logistician on a timely and responsive basis. Complete and detailed data collection plans, procedures, forms, and incident reporting procedures will be coordinated among the four parties at a pretest conference to insure that all data needs are fulfilled.

d. A field RAM engineering data collection system (e.g., controlled data collection) will be planned, budgeted, and executed to provide essential information for a field feedback and corrective action loop and for baseline data to evaluate potential requirements for future systems. As a minimum, RAM engineering data will be collected and maintained on major and selected nonmajor materiel systems. For all others, the extent of data collection after deployment will be determined by the materiel developer and as requested by HQDA or the combat developer to support specific requirements.

e. Data information exchanges, like the Government-Industry Data Exchange Program (GIDEP), should be used whenever feasible. Additional information on GIDEP can be obtained from the Officer in Charge, GIDEP Operations Center, Corona, CA 91720.

2-5. Audit trail. *a.* Materiel developers/procurers will establish an audit trail in consonance with AR 700-127 to insure traceability of essential RAM and support parameters at any time during the materiel system's life cycle.

b. The materiel developer will establish specific controls and followup procedures to insure that deficiencies discovered during all testing (DT and OT) are corrected and that an audit trail is maintained. Deficiencies which occur during early testing, for example DT/OT I, should not recur during DT/OT II or DT/OT III testing. The controls and audit trail established by the materiel developer will insure that the status of the correction of known deficiencies is periodically reviewed from the end of testing through the next major test and decision review. When DT/OT III testing is completed, the materiel developer will take action either on his own accord or as directed

by the decision authority (IPR/ASARC/DSARC) to correct, prior to deployment, those deficiencies which affect mission performance. The corrections will be incorporated into production items/systems, tested, and verified.

c. Verification that the item or system as modified by the materiel developer has had RAM deficiencies corrected will be provided by the operational tester before initial issue to Army units.

d. The combat developer will determine whether the RAM levels of performance of the items or system under test, after the corrections are applied, meet all applicable requirements.

e. The independent evaluator for OT will determine through independent evaluations (reviews) of tests, whether these corrections have insured that the tested item or system has achieved the necessary RAM levels.

f. The materiel developer will document these assessments by establishing and maintaining a RAM record on all major, nonmajor, and other designated systems throughout the materiel life cycle. This record will provide for both the current status and the historical audit trail of RAM. This record should include such information as: RAM requirements and their rationale, the Failure Definition/Scoring Criteria (FD/SC), the Operational Mode Summary/Mission Profile (OMS/MP), the RAM program plan of both Government and contractor RAM activities, the contractual RAM provisions, all test results (i.e., type of test, test condition, length, failures, data analysis, problems, and corrective actions), current and historical growth curves, development RAM status, production RAM levels, and demonstrated field RAM characteristics. The record should be a self-standing document that is added to and updated, and thus becomes a living RAM audit trail.

Section II. DOCUMENTATION

2-6. Requirements documents. *a. RAM characteristics.* RAM characteristics or other suitable measures of effectiveness will be stated in requirements documentation when deemed appropriate by the combat and materiel developers. These requirements will be stated in terms appropriate for the system, considering its intended purpose, complexity, method of acquisition, and cost effectiveness. They will be clear, quantitative, and capable of being measured, tested or otherwise verified. The attributes described and the depth of coverage in each document will depend on the peculiarities of the system and the progress of development. Requirements documents will state only those principal performance and RAM characteristics which are essential to describe the operational features of the system. Care must be taken to insure that the requirements are truly essential and do not preclude viable trade-offs. These requirements will represent the combat and materiel developers best estimate of what is needed and attainable.

b. Letters of agreement (LOA). For those programs for which it has been determined that quantitative RAM requirements will be stated in a subsequent Required Operational Capability (ROC), Letter Requirement (LR), or TDR, the LOA must outline the RAM tasks, assignments, and testing issues that must be accomplished or addressed during advanced development to adequately quantify RAM for full-scale development. By the time a ROC or LR is approved for the commencement of full-scale engineering development, sufficient knowledge must be known from the advanced development efforts governed by the LOA to develop and justify quantitative RAM requirements in the ROC, LR, or TDR when it is prepared. Thus, the following apply to LOA's:

(1) Normally, the LOA's will not contain quantitative RAM requirements. However, when deemed necessary or advantageous, quantitative RAM goals or objectives may be stated.

(2) The LOA will contain a clear statement as to whether or not future quantitative RAM requirements will be included in a subsequent ROC or LR.

(3) When the LOA states that quantitative RAM requirements will be established, then the LOA:

(*a*) Will contain a statement which commits the combat and materiel developers to initiate and complete work on the item's operational mode summary/mission profile (OMS/MP), reliability failure definition/scoring criteria (FD/SC), definitions of availability and maintainability parameters and a baseline analysis of all relevant RAM data. This information, in conjunction with other cost, technical and operational inputs will

be subsequently used to develop the RAM requirements.

(*b*) Will state whether reliability, availability, and/or maintainability will be critical issues for testing. A critical RAM testing issue establishes that issue as a testing focal point and identifies the need to collect and analyze data on this issue to provide needed information. For example, RAM will be a critical issue during early development testing if inadequate data exist to establish a RAM baseline.

(*c*) May state quantitative RAM goals or objectives. If stated, these goals or objectives will guide the advanced development effort but will not be treated as firm requirements.

(4) When quantitative RAM requirements will not be stated in a subsequent ROC or LR, then the LOA should briefly address the rationale for this and state what, if any, RAM activities are to be executed.

c. ROC's, LR's, or training device requirements (TDR's) for developmental systems.

(1) Jointly agreed to quantitative RAM requirements must be stated in the ROC, LR, or TDR, unless jointly determined by the combat and materiel developers that RAM requirements are not appropriate for the item. RAM requirements will be stated in accordance with one of the following categories.

(*a*) *RAM not required category.* This category will be used when it can be determined that RAM characteristics are not essential or applicable to an item of equipment or are included in a higher order effectiveness parameter (e.g., systems effectiveness). In those cases where it is determined that a statement of RAM requirements is not applicable, a brief statement to this effect, with rationale, will be included in the rationale annex.

(*b*) *RAM quantitative requirements category.* This category is used when specified numbers are provided. Normally, one of the following subcategories is sufficient to express the user's need:

1. Availability and reliability requirements.

2. Reliability and maintainability requirements.

(2) When either of these RAM categories is used, the following statement will precede the requirements statement. "The quantitative RAM requirements contained in this document represent the best estimate of the operational and technical requirements for this system based upon currently available knowledge. However, when information is gained from subsequent studies, trade-off analyses and cost effectiveness evaluations that indicate a change in the threat, need, or operational/technical capabilities, the combat and materiel developers will jointly initiate a change to the appropriate RAM requirement."

(3) When RAM requirements are appropriate for the ROC, TDR, or LR, their quantification will not be deferred to a later time.

(4) A mandatory RAM rationale annex will be prepared for each ROC, LR, or TDR document to justify fully the RAM category and subcategories that are used. Quantitative RAM values will be justified in the jointly prepared RAM rationale annex. For ROC's, this annex will be available for review at the time of the ROC submission to HQDA. Justification of RAM requirements in the rationale annex will include and be based on—

(*a*) The best available quantitative and qualitative estimates of the operational mode summary/mission profile (OMS/MP).

(*b*) Reliability failure definition and, when possible, scoring criteria (FD/SC) for each reliability requirement used.

(*c*) Definitions for each availability and maintainability parameter used.

(*d*) Relevant parts of the Cost and Operational Effectiveness Analysis (COEA) which substantiate the RAM requirements.

(*e*) A baseline analysis of all pertinent historical RAM data.

(*f*) An analysis of current and/or projected ceilings of RAM feasibility and attainability based on state-of-the-art considerations.

(*g*) An analysis of the RAM impact on system effectiveness and logistic supportability.

(5) Unless otherwise qualified, the stated RAM requirements represent values which apply to functional hardware used under operational conditions. As such, the quantitative values will represent the hardware in an operational environment (i.e., operated in accordance with the OMS/MP) from DT and/or OT, but normally these requirements will not include operator or maintenance errors.

(6) RAM characteristics are measures of technical and operational hardware performance and logistic supportability. These requirements are based on need and realism and will be expressed only in terms of acceptable values.

(7) Statements such as "The RAM characteristics of this system will be equal to or better than the system which it is intended to replace" will not be used. Supportable quantitative requirements will be listed instead. Additionally, individual RAM requirements which can be computed from other requirements will not be stated since they would be mathematically redundant.

2-7. Cost and operational effectiveness analysis (COEA). The COEA prepared by the combat developer will quantitatively consider and evaluate the simultaneous impact that RAM has on both system life cycle cost and operational effectiveness. This treatment of RAM in the COEA will serve as one of the means for establishing justifying or validating the RAM requirements.

2-8. Development plan (DP). The DP (AR 70-27) is the controlling document for the materiel development effort and will contain a complete description of the RAM requirements (sec II and III), RAM program plan and activities (sec III), RAM testing (sec IV), RAM resources (sec III and IV), and critical RAM issues (sec I, II, III, IV, VI). The DP interfaces with logistics planning (sec VI) and system engineering (sec III) activities.

2-9. Key management documents. The key operational hardware RAM requirements will be stated in Decision Coordinating Papers (DCP's), Defense Program Memorandums (DPM's) and Army Program Memorandums (APM's). Critical RAM issues to be addressed during development and operational test and evaluation will also be included.

2-10. Solicitations and contracts. *a.* As a result of the jointly agreed to reliability requirements stated in the ROC, LR, or TDR, the materiel developer will conduct a trade-off analysis to determine the specified value of reliability for contracting purposes. This analysis should when applicable, include an evaluation of changes in costs for development and procurement due to incremental changes in RAM characteristics versus the associated improvement in mission effectiveness and/or savings in projected life cycle cost. This trade-off analysis and the COEA will be closely coordinated efforts. The results of this trade-off analysis will be used by the materiel developer in determining the solicitation and contract specified value for reliability stated in the system specification. The materiel developer will provide the proposed specified value (SV) for reliability to the combat developer. The SV will be used by the developing agency as the design requirement to be produced and delivered by the contractor(s). The contract specified reliability value will be at a level necessary to insure demonstration of the reliability requirements stated in the requirements document.

b. Solicitations and contracts for development of materiel will include requirements in section F for RAM programs and management controls, in addition to the test and demonstration provisions and the quantitative RAM requirements in the contract specifications. These requirements will be tailored to the specific life cycle phase of the system being developed.

c. RAM incentives and award fees, will be used when they are feasible, advantageous and beneficial to the Army.

d. Contracts for the procurement of materiel will include appropriate requirements to insure that the materiel being procured is reliable, durable, supportable, and maintainable.

e. Reliability improvement warranties will be used when it is feasible, advantageous and benefical to the Army.

f. The capability of a contractor to define, design, achieve and produce materiel which meet the stated RAM requirements will be a major evaluation factor in source selection (AR 715-6). When data are available, an assessment will be made and utilized in source selection concerning the contractor's ability for RAM performance. The solicitation will contain appropriate requirements in section C for the RAM content of the contractor's proposal. As necessary, the solicitation will state the RAM evaluation factors in section D.

g. Technical data packages (TDP) will be developed with integral RAM functional characteristics for system level and key critical lower-level work breakdown structure elements. The materiel developer will place appropriate inspection and test requirements in the TDP to insure the delivery of a product that achieves its specified reliability and maintainability requirements.

h. When appropriate, the materiel developer will develop and insert RAM requirements to the lowest work breakdown structure level necessary (e.g., 3rd or 4th) in order to control the RAM characteristics to be specified in future repair part procurement actions.

Section III. RAM CHARACTERISTICS

2-11. RAM quantification. *a.* Reliability requirements will normally be quantitatively expressed as the attribute mean-time (or distance, or rounds)—between failure (MTBF, MDBF, or MRBF) except when such parameters as mission reliability, or in-flight reliability are more appropriate. MTBF, MDBF, MRBF, or mission parameters will be associated with the OMS/MP and will be accompanied by a FD/SC which describe these reliability parameters in terms of chargeable failures. Additional reliability parameters (such as, mean-time-between-unscheduled-maintenance-(MTBUMA) or mean-time-between-any-maintenance-action (MTBAMA)) will be stated when appropriate and these parameters will be associated with the overall maintenance burden of the system. Unless otherwise stated, all reliability requirements will pertain to new equipment. When appropriate, additional reliability requirements for rebuilt or overhauled equipment may be established and will be clearly labeled.

b. Determination of the reliability requirement will be jointly developed by a combat and materiel developer working group and must be agreed to by both the combat and materiel developers. The reliability requirement will be stated as both the minimum acceptable value (MAV) and the best operational capability (BOC). The MAV for reliability is defined as that value which presents the least operational capability the user can tolerate and accept. It represents a level of marginal performance which is the floor value of acceptability and below which is unacceptable. During DT/OT testing which immediately precedes the type classification (standard) decision, the MAV will have a low consumer's risk associated with it. It will normally be based on: The user's minimum requirements for mission success; the logistician's minimum requirements to provide responsive, economical logistic support; and mandatory requirements of national or international laws and agreements, such as environmental control and nuclear safety. While the MAV represents the floor of acceptability, the user's preference for reliability increases as reliability increases beyond the MAV. The BOC value for reliability is defined as that upper level of reliability which is estimated to be technically feasible for the stated time frame within reasonable cost constraints and is in consonance with the highest reliability performance for which a realistic need exists.

c. Reliability after storage may be a stated requirement. If appropriate, it will specify the amount of deterioration acceptable during storage. Length of storage, storage environment, and surveillance constraints will be identified (AR 70-38). It should be recognized that this requirement may not be testable and may rely on an engineering analysis for its assessment prior to deployment.

d. Durability requirements may be stated for systems and/or major components (e.g., engine, transmission, gun tube), and will use the most appropriate quantitative parameter(s) and durability failure definition. Durability will be periodically assessed throughout the life cycle. Durability requirements will be developed to optimize, overhaul or rebuild policies and to minimize cost.

e. Availability will be expressed as operational availability (Ao), achieved availability (Aa), inherent availability (Ai) or combinations thereof. Definitions for Ao, Aa, and Ai are in Appendix A.

f. When Ao is quantified, the following apply:

(1) While Ao parallels the intent of equipment operationally ready rates (AR 750-52), Ao is usually not synonomous with operational readiness. Ao represents a number used in the development phase to convey an approximate estimate of future equipment operationally ready rates. For the two to be directly comparable, FD and SC used in testing must be the same as Equipment Serviceability Criteria (ESC) used in operational units to derive operationally ready rates, actual equipment usage in the field must be essentially the same as the tested OMS/MP, and logistic support provided in the field must be similar to the logistic support simulated in operational testing. Due to the inclusion of both operating time and standby time, any use of Ao

must always be accompanied by an item utilization rate (i.e., amount of required operating time per some calendar time period). In a similar fashion, Ao must be factorable into its operational hardware reliability and maintainability characteristics along with total administrative and logistics downtime information in order to influence the hardware design and the design of the logistics system and the maintenance support concept.

(2) The rationale, assumptions, and data used to establish Ao criteria will be stated in relation to the mission duration or profile so that proper trade-offs can be made among reliability and maintainability characteristics with operational requirements and logistical support considerations. The description of the Ao characteristic must be explicit (i.e., available to do what, and under what operating and support environment) and will clearly define how to factor the total calendar time and how to charge incidents or system events to the Ao formula categories.

g. Mean-time-to-repair (MTTR) may be used to quantify the system's maintainability characteristic. MTTR applies to the configuration system level and will be used as an "on-system" maintainability index and not for the repair of components. It does not include off-system repairs of components that are replaced. The MTTR will be stated for both organization and direct support levels of maintenance.

h. Maximum time to repair or maximum corrective maintenance downtime may be used, if appropriate, to quantify maintainability. It will not include off-system repairs of replaced components.

i. Maintenance ratio (MR) will be a measure of the total maintenance manpower burden required to maintain a system. It is expressed as the cumulative number of man-hours of maintenance expended in direct labor during a given period of time, divided by the cumulative number of end item operating hours (or rounds or miles) during the same time. The maintenance ratio will be expressed for specific levels of maintenance and summarized for combined levels of maintenance. All maintenance actions are considered (i.e., scheduled as well as corrective, and without regard to their effect on availability of the system). Man-hours for off-system repair of replaced components or daily operational checks are not included. For items like combat vehicles, the MR requirement will state whether it is computed from system operating hours or engine hours.

j. Availability, maintainability and durability requirements will normally be expressed as single values and will be used by the materiel developer as minimum design requirements to be produced and delivered by the contractor(s) and demonstrated in tests.

k. From a RAM and logistic viewpoint, it is sometimes equally, if not more important, to quantify maintenance burden requirements in addition to or in place of operational mission requirements. In these cases an annual support cost (see appendix A) characteristics may be developed. ASC would include the direct support costs (i.e., personnel and parts) attributable to and controlled by the design.

l. As needed, a parameter to quantify "off-system" maintenance actions may be developed and stated.

2-12. Operational mode summary and mission profile (OMS/MP). *a*. The operational mode summary describes the anticipated mix of operational modes and their expected percentages of use in different operational and environmental conditions for which the system was designed throughout its life before overhaul. The mission profile describes the operational requirement(s) that a system must complete to accomplish a particular mission or set of missions (i.e., battlefield day). The operational mode summary will be based on the specific mission profile(s) that the user estimates to be the essential specific tasks the equipment will be required to perform and that portion of the life expected to be spent in these missions or other use.

b. The operational mode summary will be used to determine the RAM requirements and overall combat effectiveness. As necessary, mission reliability will be determined from the mission profile. Evaluation of life cycle costs in the COEA will include other anticipated use modes such as training. The test program will be designed to provide data for evaluation of the required characteristics in terms of the operational mode summary and also for evaluation of the specific mission profile(s) in relation to age and wear of the system.

c. The operational mode summary against which government testing (i.e., DT, OT, or both DT and OT) and evaluation are performed will be

representative of actual operational requirements. RAM characteristics will be evaluated in accordance with the relative frequency of uses defined in the operational mode summary rather than overall inclusive potential uses or at the rare extreme uses.

d. Operational mode summary/mission profile will be developed by the combat developer and coordinated with the materiel developer, the operational tester and development tester for review and comment. The OMS/MP will be developed prior to the submission of a proposed ROC to HQDA. The OMS/MP will be used as the basis for determining and including RAM parameters in the ROC, LR, or TDR. The OMS/MP will be included in the RAM rationale annex, DP, and CTP.

2-13. Failure definition and scoring criteria. *a.* For a reliability parameter like MTBF to convey meaning, an accompanying definition must be established to define what constitutes a failure and what events may be excluded. A failure definition consistent with the OMS/MP will be developed and stated in the requirements document or rationale annex thereto. The detailed scoring criteria will amplify the failure definition and will include procedures for classifying maintainability, availability and durability parameters. Detailed scoring criteria will be developed in a time phased sequence with the design evolution process. Both the failure definition and the detailed scoring criteria will be included in the DP, CTP, solicitations and contracts, and all other appropriate documents.

b. The combat developer and materiel developer will jointly develop and formally approve the FD/SC which will be used throughout the materiel life cycle process. The operational and development testers and evaluators and logistician will review and comment on the FD/SC to insure that the FD/SC can be applied during actual testing and will address the feasibility of collecting the necessary data. The FD/SC must be approved prior to the commencement of full scale engineering development. Formal agreements on FD/SC will be included in either the normal requirements or program documents or as separate agreements.

c. The materiel and combat developers will develop generalized failure definitions for each individual category of equipment (*e.g.*, combat vehicles, communications, air defense missiles). Individual scoring criteria will be developed for specific systems within each category.

d. In order to evaluate both reliability and the logistic burden, the FD/SC will normally provide for such incident classification categories as:

(1) No test—incidents which are not counted as maintenance actions or as failures.

(2) No failure—incidents requiring unscheduled maintenance but which are not failures.

(3) Failures.

(*a*) Incidents which require unscheduled maintenances, and are system failures but not mission abort failures.

(*b*) Incidents which require unscheduled maintenance and are both system and mission abort failures.

(*c*) Incidents which require no maintenance action, and are system failures but not mission abort failures.

(*d*) Incidents which require no maintenance action, and are both system and mission abort failures.

e. The approved FD/SC will be used throughout the materiel life cycle to consistently assess the RAM requirements.

f. The reliability FD/SC will clearly state the methodology and procedures to be invoked in purging obsolete failures. Obsolete failures are defined as patterned failures or failure modes which as a result of a design change and subsequent verification throughout are not expected to recur. In purging failures on development systems, considerations must be given to the effectiveness of the design fix and the fix verification through test.

g. All FD/SC jointly approved prior to the effective date of this regulation will continue in use. Specific changes directed towards incorporating the above FD/SC policies are optional.

Section IV. TESTING

2-14. Development testing (DT). *a.* DT is that testing and evaluation conducted to demonstrate, evaluate, or assess that the engineering design and development process is complete, that the design risks have been minimized, and that the system will meet specifications; and to estimate the system's military utility when it is introduced. DT is accomplished in factory, laboratory, and

proving ground environments and includes engineering design testing and human factors testing to demonstrate a satisfactory technical man (soldier)-machine interface using qualified and experienced operators, crews, and maintenance support personnel.

b. DT will be designed to provide a measure of the system RAM characteristic against stated requirements in a controlled environment with the procedures and resources contained and/or described in the Maintenance Test Support Package (AR 750-1). The DT RAM emphasis will be to identify design deficiencies and to provide valid estimates of the inherent RAM characteristics of the materiel for the purpose of providing:

(1) Assessment of RAM growth.

(2) A basis for assessing the consequences of any differences anticipated during field operations.

(3) A basis for resolution of legal (contractural) issues between the government and its contractor.

(4) Contribute data to the DT/OT RAM data base for aggregation and ROC requirements comparison (where aggregation is statistically valid).

(5) A basis for a clear identification and understanding of both failures and maintainability design deficiencies and the basis for taking corrective measures.

c. Integrated development testing for reliability will be designed and conducted to duplicate as closely as possible the anticipated field environmental profile. Tailored environmental profiles should be developed and utilized. Standard environmental profiles, like those contained in MIL-STD-781, should only be used when they are the "best fit" or when sufficient environment information is not available and cannot be generated.

2-15. Operational testing (OT). *a.* OT is testing that is conducted to estimate a prospective systems military utility, operational effectiveness, operational suitability (including compatibility, interoperability, RAM, logistic supportability, operational man (soldier)-machine interface, and training requirements), and the need for any modifications. In addition, OT provides information on organization, personnel requirements, doctrine and tactics. It may also provide data to support or verify operating instructions, publications, software and handbooks. OT will be accomplished by operational and support personnel of the type and qualifications of those who are expected to use and maintain the system when deployed.

b. OT will be designed to evaluate the RAM performance characteristics upon exposure of the materiel to a variety of expected operational conditions. OT concentrates on RAM performance when in the hands of typical user troops under operational conditions. OT provides data for the estimation of life cycle costs and logistic resource requirements and also provides a basis for improving the nonmateriel aspects of RAM performance. OT RAM emphasis will be to:

(1) Provide valid operational estimates of RAM characteristics.

(2) Contribute data to the DT/OT RAM data base for aggregation and ROC requirements comparison (where aggregation is statistically valid).

(3) Complement DT data needs by instrumenting item/system undergoing OT, recording detailed failure data, and allowing failure diagnosis by materiel developer personnel where their efforts do not detract from the validity of the OT.

(4) Determine the interaction of RAM characteristics, including system, crew and logistical support interfaces, with overall system performance.

(5) Represent, to the maximum degree possible, realistic operational conditions based on the jointly agreed to operational mode summary/mission profile.

2-16. Test documentation. The operational tester and/or evaluator and the development tester and/or evaluator will produce the following documentation which will describe the complete RAM test and evaluation plan for each major phase of testing (DT and OT I, II, and III or follow-on operational test and evaluation (FOTE)). (Reference AR 70-10.)

a. Independent evaluation plan (IEP). The evaluation methodology and criteria to be employed in the evaluator's independent evaluation with respect to RAM characteristics and logistics supportability will be included in the IEP.

b. Test design plan (TDP). All RAM testing, whether factory, laboratory, or proving ground (for DT) or operational unit (for OT) will be described and related to RAM critical issues, if

any. RAM test plans will implement the test design plan.

c. Detailed test plans (DTP). These are the tester's internal procedures for executing the tests per the TDP. RAM test plans will describe the data storage and retrival system, the statistical and engineering techniques to be used in data analysis and the type of quantitative and qualitative results to be produced.

d. Test reports. The test unit or agency assigned responsibility to conduct tests contributing to the overall evaluation will report results of RAM tests and demonstrations in detail, complete with report or estimate of the cause of the failure and the manner in which the failure occurred, and discussions of the importance and impact of defects found in system RAM.

e. Independent evaluation reports (IER). The assigned evaluators for OT and for DT will present a complete evaluation of demonstrated or predicted RAM characteristics and their assessment of the military utility or system effectiveness resulting therefrom. Departures from the results of scoring conferences will be identified for the decision-making body (IPR, ASARC, or DSARC).

2-17. Test planning and design. *a.* It is expected the DT/OT I RAM data will be primarily technical in nature but some limited operational RAM data may be obtained from this testing.

b. DT/OT II preceeds the first production decision. Prior to this decision, it is necessary to have valid estimates of the technical and operational RAM characteristics. Adequate testing must be performed in both DT II and OT II to provide these estimates. Aggregation of data, when possible, will improve the overall estimates, but normally, RAM results from either DT II or OT II will stand alone. Valid estimates of RAM characteristics from an operational environment are essential. However, the independent objectives of DT II and OT II must be maintained and not sacrificed at the expense of one test over the other.

c. Data from the DT/OT III test phase must support the decision as to whether the system should be deployed. Valid estimates of RAM characteristics from an operational environment are essential. Data will be aggregated when possible.

d. Statistically designed experiments will be used to the maximum extent possible in planning the Coordinated Test Program to assure that optimum information is obtained from the testing effort commensurate with the effective utilization of funds, resources, and time during development.

e. DT and OT will be designed to provide sufficient data to permit identification of trends in equipment failure rates (i.e., increasing, constant, decreasing) and the determination of applicable statistical distribution for reliability, availability or maintainability analysis. Reliability testing will allow assessment throughout the life cycle before overhaul, rebuild, or service life, whichever is appropriate. DT will be designed to identify failure modes and design deficiences in order that corrective action may be taken to promote reliability growth to the specified value.

f. Test planning and the design of DT and OT, will recognize that DT and OT RAM data will normally yield three different types of RAM indices: DT RAM indices, OT RAM indices, and the aggregated DT/OT RAM indices. The DT RAM indices are inherent technical hardware values. The OT RAM indices are overall system values which include failures of the human element and all other field operational factors. The aggregated RAM indices are derived from combined DT/OT test data which are processed through the FD/SC and is representative of future field use and which, when the data can be validly combined, will be used to assess the compliance with ROC or LR RAM requirements. RAM data aggregation will consider that the stated RAM requirements are normally intended to represent the technical hardware values when the hardware is operated in accordance with the OMS/MP. In cases where the RAM results from DT and from OT are expected to be different, data aggregation may not be feasible. In these cases, test plans should be structured to document the reasons for any observed differences in system performance. Differences in RAM values that may occur between DT and OT results are normal and their occurrence should not be misconstrued as unfavorable RAM indicators. Reasons for these differences may include different environments, man-machine interfaces, test designs, level of training, or differences in the precision of data collection and subsequent scoring in DT and OT.

g. Test planning will be such that all RAM data from DT and OT can be provided and exchanged among all principal parties in the

materiel acquisition process, but particularly the combat developer, materiel developer, development testers/evaluators, operational testers/ evaluators and logistician on a timely and responsive basis. Data collection requirements will be coordinated among the parties in sufficient time before test initiation to insure that all data needs are fulfilled.

h. Preparation of the coordinated test program (CTP) (DA Pam 70-21) requires analysis to verify RAM testing is adequate to—

(1) Detect patterned failures.

(2) Permit planned reliability growth.

(3) Provide an acceptable, and consistent basis for determining the systems RAM status for presentation to the decision body.

(4) Insure that both user's and producer's risks are adequately addressed.

Appropriate mathematical techniques will be employed in test design to accomplish these goals.

i. When using a quantified analysis of testing risk to assist in test design, the risk levels for DT and OT will be established based on the criticality and user impact of reliability and they will be documented in the CTP.

j. Any quantification of test risk will also include a sensitivity analysis. This total analysis in conjunction with engineering judgment and resource constraints will be used to develop the recommended test length.

k. Care must be taken to maintain a balance among DT II, OT II, DT III, OT III, and FOTE which are commensurate with test objectives and acquisition strategy. From a production decision, operational suitability and reliability growth viewpoints, the combined DT/OT II should be of greater importance than the combined DT/OT III. DT II should not be sacrificed for OT II.

l. Maximum use will be made of military maintenance personnel during early testing and mock-up evaluations. It is during this period that the greatest savings can be realized in the time and resources which will ultimately be required to maintain the equipment. The materiel developer should provide for observation/participation by military personnel in such areas as contractor testing, mock-up reviews and early maintainability evaluations.

m. Test plans for each phase of the development cycle should be designed based on the requirement and the planned reliability growth and will be different for engineering development (DT/OT II) and initial production (DT/OT III). Early development and operational test DT/OT I and DT/OT II of a system occurs at a point on the reliability growth curve that is normally less than the specified value. DT I/OT I and DT II/OT II should be designed to evaluate RAM characteristics and assure program continuation if sufficient reliability growth has been achieved. In general, sufficient reliability growth will have been achieved if the MAV is demonstrated at high confidence during the DT/OT preceding the decision to type classify standard. Improvement of reliability will be evaluated against the requirement and the projected value on the reliability growth curve for the appropriate point in the development or production phase.

n. OT II, OT III and FOTE will be designed to assess the logistic considerations of the system in conjunction with operational availability. At OT II the logistic concept will be reviewed and implemented where possible. The review, analysis, and evaluation of test results will identify potential logistic problems. At OT III or in FOTE, the logistics concept will be implemented to the maximum extent to allow an assessment of the concept on the system's operational effectiveness.

o. Normally OT II will address maintenance through general support level using trained military personnel. Characteristically, OT III will exercise maintenance support throughout GS level, with trained military personnel required through that level. In the case of tests where waivers have been granted to go into tests without the full logistic system planned, assessment of maintenance may be limited with the degree of assessment determined by the operational tester or a case by case basis.

p. Normally OT will not assess durability, but will contribute data to the developer for that assessment. The nature of durability is such that testing for it necessitates a technical assessment. A test item may be used in both DT and OT to accumulate the necessary operating time equivalent to its useful life for the assessment of durability. The operational tester will not attempt to apply a statistical significance to any such failures which occur, but such failures will be considered in evaluation.

q. The use of point estimate test criteria (para 2-19) should not be construed as permitting

the length of the test to vary without bounds. Tests should be designed such that the test length is of adequate and sufficient length to detect patterned failures, to permit reliability growth, and to control to a tolerable level the subsequent estimation variability in data analysis.

2-18. Test criteria. *a.* In accordance with AR 70-10, intra-Army reliability test criteria will be jointly defined by the materiel and combat developers for each phase of acquisition testing. Test criteria will be coordinated with the operational and development testers and included in the CTP prior to its coordination and approval for the initial phase of testing and recoordinated during CTP update. These criteria will be established using the reliability requirements, reliability growth considerations, and technological assessment of the development program. Since no single test or series of tests can provide all the information upon which to base a decision, these reliability criteria are not established as automatic "pass/fail" criteria for the system, but are criteria to measure the attainment of the reliability requirement. The test criteria will be used to assess satisfactory reliability progress in early DT and OT and to assess the demonstrated achievement of the reliability requirement at the DT/OT prior to a full production decision. The criteria are not intended to be all inclusive since issues unforeseen at planning, often arise as the result of testing. The test criteria should reflect the projected growth of system performance during the development cycle.

b. Normally the reliability test criteria will be as follows:

(1) When the material acquisition plan for a particular system calls for a low rate initial production (LRIP) decision followed by a period of testing and RAM growth prior to the full production decision, a point estimate value of the MAV will be achieved under operational conditions prior to the LRIP decision.

(2) The MAV at high confidence will be demonstrated under operational conditions in DT/OT prior to a full production decision.

c. Availability and maintainability test criteria for DT/OT prior to any type classification decision will be a point estimate which is equal to or better than the stated requirements.

d. The above test criteria are guidelines. Individual test criteria must be tailored for each system and reflect both the stated RAM requirements, the impact on system performance of achieving various RAM levels and the available testing resources.

Section V. ASSESSMENTS

2-19. Scoring conferences. *a.* Formal scoring conferences between the materiel developer proponent, combat developer proponent, (preferably the same representatives who established the FD/SC) operational tester, operational evaluator, development tester, and the development evaluator will be held during and/or immediately after the conduct of a test to assure that a proper and consistent determination is made for categorizing test data to permit the assessment of the reliability, availability, and maintainability ROC requirements. Results (includes incident chargeability and minority opinions) of the scoring conferences will be included in the applicable test report. Minutes of the scoring conferences will be provided to the attendees and designated logistician.

b. The objective of the scoring conference is to establish a test data base to assure that a proper and consistent determination is made for categorizing test incidents as failures chargeable against RAM requirements. To accomplish this objective, scoring conferences must jointly establish the facts surrounding test incidents, determine if the facts warrant classifying the test incidents as chargeable failures in accordance with the scoring criteria, and agree upon the test incident facts and classifications. The result of the process is a single test data base identifying test length (hours, distance, or rounds) and chargeable incidents which all parties agree to use in assessing the achievement of RAM requirements. However, a clear distinction must be made between agreeing on the test data base (the facts) and the analysis of that data base (the interpretation of the facts). Subsequent independent evaluations or assessments will address the achievement of RAM or the impact of what happened during test. The independent evaluators may analyze the test data base in any appropriate manner as long as any deviations from the agreed upon classification are clearly identified.

c. The materiel developer proponent, combat developer proponent, operational evaluator, and development evaluator will each designate a single spokesman prior to the scoring conference. These spokesmen must have the authority to speak for their Agency. Decisions on chargeable failures will be through the unanimous consensus of the principal spokesman. If unresolved differences do exist, the differing opinion(s) will be formally documented in the minutes of the meeting. The incident chargeability for the assessment of RAM requirements will then be based on the majority opinion. In those cases where there is no majority opinion, the combat developer proponent will make the final determination of incident chargeability.

d. The materiel developer proponent will chair all DT scoring conferences, while the operational evaluator will chair all OT scoring conferences. The evolution of the DT, OT and, if possible, aggregated DT/OT numbers will be through these scoring conferences. At the completion of OT, there will be a final conference, chaired by the operational evaluator for the purpose of reviewing all DT and OT RAM data, establishing a valid aggregated data base, and developing the aggregated RAM numbers.

e. The operational evaluator, developer evaluator, combat developer and materiel developer will determine what data may be aggregated. Two factors will be considered in determining if data can be aggregated. First, data from DT to be aggregated with OT data must come from testing that was conducted in accordance (approximate) with the OMS/MP. That is, conditions must be operational and include utilization rates in accord with the OMS and maintenance procedures. If it is agreed such conditions did exist in DT and/or OT then the second factor, that of valid statistical data correlation must be considered. The aggregated RAM values will be reported to the ASARC/DSARC/IPR decision review by the operational evaluator with the rationale supporting aggregation. When data cannot be aggregated, then both the DT and the OT results will be presented.

f. The development tester or the operational tester will provide a representative to all scoring conferences. This representative will act in an advisory capacity to provide explanations and background information on the conditions of tests for each incident along with resulting maintenance actions and hardware conditions or failure analysis.

g. The development and operational testers will determine initial failure chargeability classifications. Final chargeability classification is the responsibility of the scoring conference.

2-20. Test assessment. *a.* The DT and OT test data base which has been formally processed through the scoring conference process and the aggregated DT/OT data from the final conference will be used when assessing the achievement of RAM requirements.

b. A quantitative RAM assessment of test results will be performed using valid and appropriate analysis techniques. Quantitative impact on the analysis due to changes in the assumptions (i.e., other distributions) will be assessed. This quantitative assessment will be included in DT and OT evaluations.

c. The results of RAM testing will be assessed and portrayed in test reports, independent evaluations and assessments in a suitable form for review by and use in the decision making process (IPR/ASARC/DSARC). This will include the following:

(1) Comparison of the demonstrated reliability point estimate to the MAV. Comparison of the availability and maintainability point estimates with the stated requirements.

(2) Portrayal of a range of reliability confidence limits (one and two sided) based on an appropriate analysis of the test data.

(3) Display of the user's risk and degree of confidence associated with the MAV.

(4) A failure analysis which will identify the frequency of part and/or failure mode occurrences, the impact of these failures on mission performance and logistics burden, and any safety considerations as a result of critical and/or catastrophic failures.

(5) A discussion of training requirements, skill levels, and logistic support which are impacted because of the RAM test results and other nonmateriel aspects of RAM.

d. The independent evaluator for OT will provide an operational RAM assessment of the total system, including all mission essential equipment. This operational assessment will normally be mission effect oriented, will consider failures of the total system, and will include incidents resulting from operator or maintenance errors.

e. Based on the DT and OT results, the materiel

developer will provide an assessment as to the ease or difficulty of developing and incorporating design changes to eliminate selected failure modes and the quantitative impact of these changes on reliability.

f. The maintenance burden and the maintenance concept will be assessed using developmental and operational testing results.

g. The DT maintainability/maintenance assessment will determine the appropriate maintainability indices and the degree of adherence to good maintainability and human factors design principles. DT maintenance evaluation will also determine whether the equipment publications, tools, test, measurement and diagnostic equipment have been developed to the point that the complete system is ready for operational testing. The DT maintenance evaluation will be performed in part by military personnel under controlled conditions. No attempt will be made to provide the normal range of personnel training or operational environments during DT.

h. The OT maintenance assessment will consider the ability of the using troops to maintain the system with the tools, equipment publications and skills available in an operational environment. OT will consider the impact of the design on the user, and will include a comprehensive assessment of publications, tools, skill levels and allocation of tasks. Typical spectra of troop skills and varied environmental backgrounds will be normal components of OT maintenance evaluation.

2-21. RAM assessments. *a.* Throughout all phases of the materiel life cycle, the materiel developer will conduct repeated RAM assessments of the design and of the hardware's measured and predicated RAM characteristics.

b. During the course of establishing and documenting quantified RAM parameters for requirements documents, the materiel developer will perform a baseline analysis to assess the technical realism of proposed RAM requirements. The purpose of a baseline analysis is to utilize past data, engineering analysis, and predictions to assess and/or challenge proposed RAM parameters. The baseline analysis will also evaluate the suitability of the proposed RAM values, considering their cost effectiveness in performing realistically stated missions or operating scenerios. Such an analysis on the part of the materiel developer will assist in determining what quantitative levels of RAM are feasible and attainable within program constraints, and determining what trade-offs to consider when evaluating the benefits, effects, or burdens of various RAM levels in performing intended missions or scenerios.

Section VI. NONDEVELOPMENT ITEMS

2-22. General. Nondevelopmental items, include the categories of commercial nondevelopment items (CNDI) and military adaptation of commercial items (MACI) and items developed and accepted by another Military Service or government agency or a foreign country. RAM characteristics for nondevelopmental items will be consistent with the standards of commercially designed equipment. Characteristics required to meet the operational or logistic need will be set forth in terms currently used by industry for that type of materiel and will be considered in the technical evaluation associated with selection of candidate items. Assessments and plans should indicate any evaluations of nondevelopmental items and the likelihood that these could meet the operational need including any stated RAM requirements. If appropriate, the nature of any military adaptation needed to meet stated requirements will be indicated in the technical assessment together with an evaluation of the effects of the adaptation upon the RAM characteristics.

2-23. Requirements. *a.* RAM characteristics or other suitable measures of effectiveness essential to meeting the operational and logistic needs must be stated in requirements documents for such materiel. Technical assessments should indicate pertinent information regarding nondevelopmental items to include the likelihood that these could meet the required RAM and other materiel characteristics. Technical assessments should also indicate the reasons for omission if certain RAM characteristics are not included in the requirements document.

b. The materiel developer should give appropriate consideration for using RAM warranties in solicitations and contracts for nondevelopmental items.

to type classification (AR 71-6) to provide satisfactory evidence of acceptability for the anticipated Army utilization (including the operational, manpower and logistic environment). The evaluation will take advantage of data from the developing/procuring agency, contractors and/or users of the item to the maximum possible extent in order to avoid unnecessary testing. A Coordinated Test Program (CTP) will be prepared in all cases to identify required testing or the equivalent evaluation information (AR 70-10). Results of testing or equivalent evaluation information will be a consideration in the determination of suitability made by the appropriate decision review.

b. Procurement documents will include a description of any tests to be conducted and test objectives and criteria to be used to permit certification that the item satisfies the approved requirement and will designate the organization responsible for conducting the test. RAM characteristics included in documents used to procure commerical nondevelopmental items will be stated in terms consistent with those used by industry for that type of materiel. Similar consistency applies to procurement of other nondevelopmental items.

Section VII. RECONDITIONED MATERIEL

2-25. General. *a.* The objective in reconditioning materiel is to provide the user with materiel that satisfies the user's need. It is incumbent upon materiel developers to establish, in conjunction with the user, appropriate quantitative RAM requirements in the reconditioned materiel technical data or standard.

b. For new reconditioned standards developed on or after the effective date of this regulation, the materiel developer will insure that RAM is adequately addressed in each standard. For existing reconditioned standards, the materiel developer will establish a program to formally review and change, if necessary, the RAM requirements of reconditioned standards.

2-26. Testing. The materiel developer will conduct RAM demonstration tests to insure that the reconditioned materiel meets the RAM requirements stated in the standard.

2-27. Assessing. *a.* A product assessment will be performed to assess the total reconditioning process including such things as technical data, kits and components, process and procedures, configuration control, inspection and test equipment, and hardware testing.

b. Appropriate field data collection programs will be established to measure and assess the field performance of reconditioned equipment.

c. In conjunction with the overall assessment of fielded items, a comparison of field performance for reconditioned items versus similar new production items will be made.

APPENDIX A
EXPLANATION OF TERMS

A-1. Annual support cost (ASC). This is the direct, annual cost of maintenance personnel, repair, parts and transportation for all corrective (either on-system, off-system, or both) and preventive maintenance actions when the system operates "X" hours per years during the "Nth" year of "M" years service life where the system is defined as Y units of item A, Z units of item B, etc.

A-2. Assess. Make an objective determination of the degree to which the system under test met specified performance criterion, based on the facts available from testing.

A-3. Availability. A measure of the degree to which an item is in operable and committable state at the start of the mission, when the mission is called for at an unknown (random) point in time (MIL-STD-721B).

A-4. Availability (Inherent). The percentage of time the system is operating when considering only operational time and unscheduled (corrective) maintenance time. The formula is:

$$A_i = \frac{OT}{OT+TCM}$$

Where:

OT = The operating time during a given calendar time period.

TCM = The total corrective maintenance time in clock hours during the stated period.

A-5. Availability (Achieved). The percentage of time the system is operating when considering only operating time and total maintenance (scheduled and unscheduled) time. The formula is:

$$A_a = \frac{OT}{OT+TCM+TPM}$$

Where:

OT, TCM are defined in A-4 above.

TPM = The total preventive maintenance time in clock hours during the stated OT period.

A-6. Availability (Operational). This parameter is a measure of the degree to which an item is either operating or is capable of operating at any random point in time when used in a typical maintenance and supply environment. This definition covers total calendar time where:

$$A_o = \frac{OT+ST}{OT+ST+TCM+TPM+TADLT}$$

$$= \frac{\text{Total calendar time} - \text{total downtime}}{\text{Total calendar time}}$$

OT = Operating time per given calendar time period.

ST = Standby time (not operating, but assumed operable) per given calendar time period.

TCM = Total corrective (unscheduled) maintenance time per given calendar time period.

TPM = Total preventive (scheduled) maintenance time per given calendar period.

TALDT = Total administrative and logistics downtime spent waiting for parts, maintenance personnel or transportation per given calendar time period.

A-7. Combat developer. The command or agency responsible for the formulation of concepts doctrine, organization (excluding Army wholesale logistics) and materiel objectives, and requirements for the employment and support of US Army forces in a theater of operations and in the control of civil disturbances. The combat developer formulates Army management systems (in logistics, personnel, administrative, training, and other functional areas as designated) which impact directly on or extend into a theater of operations. The combat developer formulates the Army structure (US Army Training and Doctrine Command (TRADOC) is the Army's principal combat developer.).

A-8. Critical item. Any part or item that (1) prevents satisfactory operation of the system or creates unwarranted safety hazards if it fails to function, (2) is sufficiently complex to warrant special production techniques or controls, (3) requires special treatment or handling during transport or storage, (4) imposes a heavy maintenance and supply support burden, or (5) has a long production lead time.

A-9. Development. Systematic use of scientific knowledge directed toward—

a. Improving or creating useful products to meet specific performance requirements but excluding manufacturing and production engineering.

b. Creating components for end items to meet specific performance requirements.

A-10. Development plan (DP). A document which records program decision, contains the user's requirement, provides appropriate analysis or technical options, and the life cycle plans for development, testing, production, training, and logistic support of materiel items (AR 70-27).

A-11. Durability. A special case of reliability (MIL-STD-721B). Durability is the probability that an item will successfully survive its projected life, overhaul point, or rebuild point (whichever is the more appropriate durability measure for the item) without a durability failure. A durability failure is considered to be a malfunction that precludes further operation of the item and is great enough in cost, safety, or time to restore, that the item must be replaced or rebuilt.

A-12. Effectiveness. A measure of the extent to which an item satisfies a set of specific, pre-established requirements.

A-13. Failure. The inability of an item to perform within previously specified limits (MIL-STD-721B).

A-14. Failure modes. The ways in which an item can fail, including the type of failure (e.g., short, open, fatigue) and degree of failure (e.g., partial, total).

A-15. *Item.* A unit of materiel at any level of assembly (e.g., weapon system, subsystem, component) (MIL-STD-721B).

A-16. Life cycle. All phases through which an item passes from conception through disposition (DA Pam 11-25).

A-17. Maintainability. A characteristic of design and installation which provides inherently for the item to be retained in or restored to a specified condition within a given time, when the maintenance is performed in accordance with prescribed procedures and resources.

A-18. Maintainability engineering. The application of scientific knowledge and engineering skills to the development of items of Army equipment to provide an inherent ability to be maintained (i.e., favorable maintenance characteristics).

A-19. Maintenance. All actions necessary for retaining an item in or restoring it to a specified condition (MIL-STD-721B).

A-20. Materiel developer. The agency responsible for research, development and production validation of an item (to include the system for its logistical support) which responds to DA objectives and requirements (AR 70-1).

A-21. Mean-time-between-failure (MTBF). For a particular interval, the total functioning life of an item divided by the total number of failures during the measurement interval. The definition applies to time, cycles, distance, events, or other measures of life units (MIL-STD-721B).

A-22. Mean-time-to-repair (MTTR). The total corrective maintenance time divided by the total number of corrective maintenance actions during a given period of time (MIL-STD-721B).

A-23. Mission profile. A description of the operational requirement(s) that a system must complete to accomplish a particular mission or set of missions. This profile will be used as the basis for mission reliability assessment. The tasks may be multifunctional (an item performing several tasks such as a tank shooting, moving, and communicating); single-function continuous (an item continuously performing one task such as a surveillance radar); single-function cyclic (an item performing the same task repeatedly such as a missile launcher or artillery piece); or single-function one-time (an item performing only a one-time task such as a missile or munition) and described in terms such as hours, miles, or rounds fired.

A-24. Operational mode summary. A description of the anticipated mix of ways the equipment will be used in carrying out its operational role. Includes expected percentage of use in each role and percentage of time it will be exposed to each type of environmental condition during the system life.

A-25. Operational performance characteristics. System characteristics fundamental to the effectiveness of a mission, including characteristics such as speed, range, and accuracy.

A-26. Reliability. The probability that an item will perform to its intended function for a specified interval under stated conditions (MIL-STD-721B).

A-27. Specified value. The value specified in the contract or equipment specification (MIL-STD-781B).

A-28. Supporting agency. The agency responsible for planning or carrying out integrated logistic support embracing one or more of the following disciplines: Maintenance, supply (including procurement), transportation, personnel, training, facilities, and data collection and analysis.

A-29. Systems engineering. The application of scientific and engineering knowledge to the planning, design, construction, and evaluation of man-machine systems and components. It includes the overall consideration of possible methods for accomplishing a desired result, determination of technical specificaton, identification and solution of problems between parts of the system, development of coordinated test programs, assessment of data, integrated logistic support planning, and supervision of design work.

A-30. Technical performance characteristics. System characteristics that describe aspects of the system such as reliability, maintainability, safety factor, and electromagnetic field.

A-31. Thresholds. A minimum or maximum value established for each characteristic which, when breached, will cause a program review (ASARC/DSARC/IPR, as appropriate).

APPENDIX B

RELATED ARMY PUBLICATIONS

AR 5-4	Department of the Army Productivity Improvement Program
AR 10-5	Organization and Functions Department of the Army
AR 11-13	Army Electromagnetic Compatibility Program
AR 11-14	Logistic Readiness
AR 15-14	Systems Acquisition Review Council Procedures
AR 70-1	Army Research, Development, and Acquisition
AR 70-5	Grants to Nonprofit Organizations for Support of Scientific Research
AR 70-8	Human Resources Research Program
AR 70-10	Test and Evaluation During Development and Acquisition of Materiel
AR 70-15	Product Improvement of Materiel
AR 70-27	Outline Development Plan/Development Plan/Army Program Memorandum/Defense Program Memorandum/Decision Coordinating Paper
AR 70-37	Configuration Management
AR 70-38	Research, Development, Test, and Evaluation of Materiel for Extreme Climatic Conditions
AR 71-1	Army Combat Developments
AR 71-3	User Testing
AR 71-5	Introduction of New or Modified Systems/Equipment
AR 71-6	Type Classification/Reclassification of Army Materiel
AR 71-7	Military Training Aids and Army Training Aids Centers
AR 71-9	Materiel Objectives and Requirements
AR 95-33	Army Aircraft Inventory, Status, and Flying Time, Requirement Control Symbol (RCS) DRC-130
AR 385-16	System Safety
AR 602-1	Human Factors Engineering Program
AR 700-47	Defense Standardization Program
AR 700-51	Army Data Management Program
AR 700-90	Army Industrial Preparedness Program
AR 700-127	Integrated Logistic Support
AR 715-6	Proposal Evaluation and Source Selection
AR 750-1	Army Materiel Maintenance Concepts and Policies
AR 750-37	Sample Data Collection—The Army Maintenance Management System (TAMMS)
AR 750-43	Test, Measurement, and Diagnostic Equipment
AR 1000-1	Basic Policies for Systems Acquisition by the Department of the Army
DA Pam 11-25	Life Cycle System Management Model for Army Systems

The proponent agency of this regulation is the US Army Materiel Development and Readiness Command. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) to Cdr, DARCOM, ATTN: DRCQA-E, 5001 Eisenhower Ave, Alexandria, VA 22333.

By Order of the Secretary of the Army:

BERNARD W. ROGERS
General, United States Army
Chief of Staff

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Major General, United States Army
The Adjutant General

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APPENDIX D

MIL-STD-2068(AS)

MILITARY STANDARD

RELIABILITY DEVELOPMENT TESTS

MIL-STD-2068(AS)
21 March 1977

MILITARY STANDARD
RELIABILITY DEVELOPMENT TESTS

FSC MISC

DEPARTMENT OF THE NAVY

NAVAL AIR SYSTEMS COMMAND

WASHINGTON, DC 20361

RELIABILITY DEVELOPMENT TESTS

MIL-STD-2068(AS)

1. This Military Standard has been approved for use by the Naval Air Systems Command, Department of the Navy, and is available for use by all Departments and Agencies of the Department of Defense.

2. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be of use in improving this document should be addressed to Engineering Specifications and Standards Department (Code 93) Naval Air Engineering Center, Lakehurst, NJ 08733.

FOREWORD

The reliability achieved by military systems is directly dependent upon the reliability requirements imposed, and upon the emphasis placed on reliability by (government and contractor) management throughout the life cycle. MIL-STD-785 provides criteria for a reliability program to aid in the timely and economical attainment of reliability requirements. The purpose of this standard is to amplify the requirements for the reliability development testing included in the reliability program covered by MIL-STD-785. The test program resulting from implementation of this standard should be coordinated and integrated with other design, development, and production functions to permit the most economical achievement of overall program objectives.

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1. SCOPE

1.1 Purpose. This standard established requirements and procedures for a reliability development test to implement the MIL-STD-785 requirement for such a test. The purpose of the reliability development test is reliability growth and assessment to promote reliability improvement of systems and equipments in an orderly and standardized manner.

1.2 Application. This standard is applicable to Naval Air Systems Command procurements for development of systems and equipment. This standard addresses only the reliability development test phase of MIL-STD-785 and the reliability program plan. The reliability development tests do not replace the design, performance, environmental, preproduction, individual, qualification, or other required tests specified for the system or equipment. In accordance with the approved reliability program plan, tasks such as those described in Appendix A shall be completed and approval obtained from the procuring activity prior to the initiation of reliability development tests. This standard does not apply to "single-shot" and passive use" devices such as cartridges, helmets, garments, etc.

2. REFERENCED DOCUMENTS

2.1 Issues of documents. The following documents of the issue in effect on the date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

SPECIFICATIONS

MILITARY

MIL-C-45662	Calibration System Requirement

STANDARDS

MILITARY

MIL-STD-280	Definitions of Item Levels, Item Exchangeability, Models and Related Terms
MIL-STD-480	Configuration Control - Engineering Chages, Deviations and Waivers
MIL-STD-721	Definitions of Effectiveness Terms for Reliability, Maintainability, Human Factors and Safety
MIL-STD-781	Reliability Tests: Exponential Distribution
MIL-STD-785	Reliability Program for Systems and Equipment
MIL-STD-810	Environmental Test Methods

HANDBOOKS

MILITARY

MIL-HDBK-472	Maintainability Prediction

PUBLICATIONS

NAVAL AIR SYSTEMS COMMAND

AR21 Aeronautical Requirements Ground Support Equipment

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

DEFINITIONS

3.1 Terms. Meanings of terms not defined herein are in accordance with the definitions in MIL-STD-721, MIL-HDBK-472, and AR-21.

3.1.1 Contractor. The term "contractor" is defined as any corporation, company, association, or individual which undertakes performance under the terms of a contract, letter of intent or purchase orders, project orders, and allotment, in which this document may be incorporated by reference. For the purpose of this document, the term "contractor" includes government operated activities under an airtask, project order, or allotment.

3.1.2 Corrective action. A documented design, process, procedure, or materials change to correct the true cause of a failure. Part replacement with a like item does not constitute appropriate corrective action.

3.1.3 Failure. Details involving failure criteria must be stated in the equipment specification and test procedures. For test purposes failure shall include:

a. The inability of an item to perform its required function within specified limits under stated conditions. Failure includes intermittent cessation of performance or lack of response to a command.

b. Mechanical or structural parts or components of an item broken, fractured, or damaged during environmental testing or operation within specified stress limits.

3.1.4 Environments. The conditions, circumstances, influences, stresses and combinations thereof, surrounding and affecting systems or equipment during storage, handling, transportation, testing, installation, and during use in standby status and mission operation.

3.1.5 Failure analysis. The identification of the failure mode, the failure mechanism, and the cause (i.e., defective soldering, design weakness, contamination, assembly techniques, etc.).

3.1.6 Mechanism of failure. The original defect which initiated the failure or the physical process by which the degradation proceeded to the point of failure, identifying quality defects, internal, structural, or electrical weakness and, where applicable, the nature of externally applied stresses which led to failure.

3.1.7 Mode of failure. The effect by which a failure is observed. Generally, describes the way the failure occurs and tells "how" with respect to operation.

3.1.8 Predicted reliability. That reliability which is expected at some future date, postulated on analysis of the design and the failure rates.

3.1.9 Reliability assessment. An estimate of the achieved reliability obtained by calculation using data gathered during tests.

3.1.10 Reliability growth. The positive improvement of the reliability of equipment through the systematic and permanent removal of failure mechanisms, regardless of their sources, by taking corrective action.

3.1.11 Specified mean time between failure (θ_o). The MTBF value specified in the equipment specification or contract.

4. GENERAL REQUIREMENTS

4.1 General. The reliability development test shall be planned and conducted in accordance with this standard to provide engineering information on failure modes and mechanisms under natural and induced environments, to provide information needed for assessing the reliability of equipment, and to provide for reliability improvement by the iterative process of "test, analyze, and fix". The program required by this standard differs from that required by MIL-STD-781 in that this program does not have as an objective the demonstration of any specific quantitative reliability requirement or the acceptance of hardware, but, rather, it has as an objective the assurance that the majority of the reliability problems have been resolved.

4.2 Test plan. The contractor shall prepare a reliability development test plan and obtain approval from the procuring or user activity prior to the commencement of testing. The test paln shall reflect the requirements of the contract, equipment specification and this document. Test planning shall consider the possibility of special tests to verify corrective action implementation and to obtain test data that reflect the effectiveness of corrective action implementation. The test plan shall, as a minimum, include the following:

a. Test objectives and requirements including planned growth,
b. Test item description and number to be tested,
c. Test conditions, environmental, operational, and performance profiles, and the duty cycle,
d. Test schedules and milestones, including the test program review schedule,
e. Test conduct ground rules, failure criteria, interface boundaries, and "No Test" criteria,
f. Test facility and equipment descriptions and requirements,
g. Data collection and recording requirements,
h. Analysis requirements and methods of calculation,
i. Government Furnished Property requirements and impact,
j. Description of preventive maintenance to be accomplished during test, and
k. Final restoration and disposition of test items.

4.3 Test levels. The test levels describe the condition of temperature, vibration, humidity, equipment inputs (e.g., input voltage, hydraulic pressure, torque, etc.), and the cycling of these conditions to be applied to the test items(s) during the test. The equipment inputs, the environmental conditions, and the combinations of environmental types and levels to be applied during tests and their variation as a function of test time, shall be as specified in the equipment or model specification and described in the test plan. The specified test levels shall be tailored to the system or equipment mission and environmental profiles. The following conditions are representative, but not necessarily all inclusive.

4.3.1 Temperature. The temperature requirements, including temperature cycling shall be as specified in the equipment or model specification and described in the test plan. Unless otherwise specified, a thermal survey shall be made in accordance with MIL-STD-781 prior to the start of the reliability development tests using the high and low storage temperatures as specified in the equipment or model specification. (See 5.1.3)

4.3.2 Vibration. Unless otherwise specified, the test item shall be subjected to externally imposed random, psendo-random, complex motion, or acoustic vibration excitation. The levels, tolerances and durations shall be as specified in the equipment specification. The mounting of the test item shall be in accordance with MIL-STD-810, Method 514. Unless otherwise specified, a vibration survey to determine test item resonances shall be made in accordance with the requirements of MIL-STD-810 prior to the start of the reliability development tests.

4.3.3 Equipment inputs. Unless otherwise specified, the inputs (voltage hydraulic pressure, torque, etc.) to the test item shall be varied above and below the nominal values to the levels specified in the equipment or model specification. Each input value (maximum, nominal, and minimum) shall be maintained for one-third of the equipment on time. This cycling procedure is to be repeated continuously throughout the test as described in the approved test plan.

4.3.3.1 On-Off cycling. For test purposes, the number of times that equipment will be turned ON for preoperational checks or run-ups, plus the number of times turned ON and OFF from the completion of one operational mission to the completion of the next, shall be as specified in the equipment or model specification. Additional On-Off cycling for normal maintenance and repair shall not be included.

4.3.3.2 Duty cycle . The equipment duty cycle, the time phase apportionment of modes of operation and function(s) to be performed by the test item during test, shall be as specified in the equipment or model specification. Alternative duty cycles, when applicable, shall also be as specified.

4.3.4 Humidity. Humidity shall be as specified for condensation, frosting, and freezing conditions expected during service use of the equipment under test. Humidity levels need not be controlled during the test but, at appropriate times during the test, moisture may be injected to obtain the specified condensation, frosting, or freezing conditions.

4.4 Test facilities and apparatus. Test facilities, chambers, and apparatus used in conducting the tests shall be capable of providing and maintaining the conditions specified for the applicable test levels. The test facilities and apparatus shall be described in the test plan.

4.4.1 Tolerance of test conditions. Unless otherwise specified, tolerances of test conditions shall be as specified in MIL-STD-810.

4.4.2 Accuracy of test apparatus. The accuracy of instruments and other test equipment used to control or monitor the test parameters shall be verified periodically in accordance with the requirements of MIL-C-45662 and to the satisfaction of the procuring or user activity.

4.5 Performance of test. The electrical and mechanical performance outputs and characteristics to be monitored and measured before, during, and after the tests, including the quantitative range of acceptable performance for each parameter, shall be as defined in the equipment or model specification and described in the test plan. Any performance outside these limits shall be recorded as a problem or failure, whether or not the equipment ceases to operate.

4.5.1 Pretest performance. Unless otherwise specified, prior to conducting any test, the test item shall be tested and a record shall be made of all data to determine compliance with required performance and to provide reference levels or criteria for checking desired performance of the test item during and at the conclusion of the tests. The pretest performance check may be made after installation of the item in the test facility if installation conditions necessitate it.

4.5.2 Installation of test item in test facility. Unless otherwise specified, the test item shall be installed in the test facility in the manner described in MIL-STD-810. After test item installation, the equipment and the test facility shall be operated to determine that the test set-up operates properly under the required test conditions.

4.5.3 Performance during test. The performance measurements taken during the test shall be as specified in the equipment or model specification and described in the test plan. The specified measurements taken during the test shall be compared to the pretest data to determine whether test exposure is producing changes in performance. The specified performance parameters shall be monitored so as to record problems or failures at the time they occur during the duty cycle. Periodic monitoring schemes appropriate to operational use may be used when approved by the procuring activity. Built-in test (BIT) included as part of the equipment design shall be used as part of the problem or failure detection method.

4.5.4 Post-test performance. Unless otherwise specified, the test item shall be tested at the completion of the test, and a record shall be made of all data, and the results compared to the pretest data to determine any change in performance.

4.5.5 Maintenance. Maintenance during this test shall be limited to repair of failures, correction of failures, and the preventive maintenance specifically defined in the test plan. If parts are replaced based on the preventive maintenance defined in the test plan, such replacement shall be classified as a failure and appropriate action

shall be taken, but such failure shall not be counted for purposes of the reliability assessment. Adjustments of controls which could not be accomplished readily during a mission shall be classified as a failure and appropriate action shall be taken. Unless otherwise specified, the maintenance time for each problem, failure, or maintenance action shall be documented for inclusion in the final report (see 4.9.3). The maintenance time shall be subdivided into the following categories as defined in MIL-HDBK-472:

a. Localization,
b. Isolation,
c. Disassembly,
d. Interchange,
e. Reassembly,
f. Alighment,
g. Check-out, and
h. Total

4.5.6 Test records. Test records shall be maintained continuously and as specified in the equipment or model specification and described in the test plan. When not specified, they shall be maintained in general accord with the following.

4.5.6.1 Test log and data record. The test log and data record shall be a complete record of required test data for each item under test and shall be maintained throughout the test. The format shall permit ready reference of the test history of each test item. Completed test log sheets may be duplicated but not recopied prior to submission to the procuring activity. An entry shall be made in the test log and data record each time a test item is checked. The date, time, time meter reading, the environmental conditions, and the exact values of any parameters measured shall be recorded.

4.5.6.2 Test item failure record. A failure record shall be maintained for each test item. The record shall be designed to permit keeping the entire test history of each test item on a single sheet so that widely divergent differences in test behavior between test items may be easily recognized. The test item problem and failure record shall be prepared as described in the test plan and an entry made on the occurrence of each problem or failure.

4.5.6.3 Failure tag. A failure tag shall be affixed to the test item immediately upon detection of any problem or failure. The failure tags will provide space for the problem and failure report serial number and for other pertinent entries from the test log and test item failure record. Failure tags shall be prepared as described in the test plan.

4.6 Failure reporting, analysis, and corrective action. The contractor shall implement and maintain and shall require subcontractors also to implement and maintain a comprehensive system for identifying,

reporting, investigating, analyzing, and correcting all problems and failures which occur throughout the reliability development test program. The contractor's existing failure reporting, analysis, and corrective action system may be utilized with minimum changes necessary to meet the requirements of this document. The system shall cover all test items and the interfaces between the test items and the test equipment, test procedures, test personnel and the handling and operating instructions. The system shall provide for investigation and engineering analysis of each problem or failure, followed where appropriate by laboratory analysis of failed items.

4.6.1 Problem and failure action. At the occurrence of a problem that affects satisfactory operation of the equipment as described in the test procedure, or a failure, entries shall be made on the appropriate data logs and the equipment removed from test. After this equipment has been returned to specified operating condition, it may be returned to test with appropriate entries in the data logs. Unless otherwise specified, temporary replacement of plug-in items is authorized to permit test continuation while troubleshooting, repair, and analysis are performed. Individual acceptance tests on repaired items shall be performed prior to reinstallation in the test facility.

4.6.2 Problem and failure report. A problem and failure report shall be prepared at the occurrence of each problem or failure. The report shall contain the necessary information to permit determination of the origin and possible correction of failures. The contractor's existing problem and failure report form may be used with minimum changes necessary to meet the requirements of this document. The information to be recorded shall include, as a minimum, the following:

a. Information which will indicate symptoms of failure, test conditions, identification of failed equipment, total test time, and test item operating time at time of failure shall be recorded at the time the problem and failure report is initiated.

b. Information for each independent and dependent failure and the extent of confirmation of the failure symptoms, the identification of the failures, and a description of all repair action taken shall be recorded at the time of repair.

c. Information which indicate the results of the investigation, the analysis of all part failures, an analysis of the equipment design, and the corrective engineering action taken shall be recorded at the completion of the failure investigation. If no corrective engineering action is taken, then such decision must be justified.

4.6.3 Investigation and analysis of problems and failures. The cause of each problem and failure shall be determined by investigation and analysis. The investigation and analysis shall be adequate to assess causes, mechanisms, and potential effects of the problem or failure and to serve as a basis for decision on the corrective actions. Investiga

tion and analysis shall consist of any applicable method (such as test, application study, dissection, x-ray analysis, microscopic analysis, spectrographic analysis, etc.) which may be necessary to determine the cause of failure. The investigations and their conclusions shall be documented and shall, as a minimum, provide the following information:

a. Failure date and time,
b. Necessary design changes have been devised and accomplished,
c.. Necessary design changes have been verified by test,
d. Effectivity of corrective action has been established,
e. The corrective action has been made in existing identical items to which it is pertinent,
f. The closeout document has been signed off by the appropriate contractor technical management authority to indicate technical review and to certify completion of all closeout actions, and
g. Procuring or user activity has concurred in all actions taken or to be taken.

4.6.4 Corrective action. When the cause of a problem or failure has been determined, a corrective action shall be developed to reduce or prevent the recurrence of the problem or failure. The effectiveness of the corrective action shall be demonstrated by being tested under the same controlled conditions under which the original failure was observed. Unless otherwise specified, change control procedures shall be in accordance with MIL-STD-480 change procedures for the engineering and operational testing phases of a program.

4.6.5 Classification of failures. For the purpose of reliability growth assessment, all failures shall be classified as specified in Appendix B.

4.7 Reliability growth assessment. Reliability growth assessment is obtained by calculation using data obtained from tests. The reliability of the equipment shall be monitored throughout the test by graphic plots. The vertical axis of the graph will show the appropriate reliability parameter (MTBF, probability of mission success, etc.) of the item. The horizontal axis will be in units of cumulative test time (hours, cycles, rounds, multiples of MTBF, etc.) The specified reliability value will be shown by a horizontal line corresponding to that value on the vertical axis. The current reliability plots shall be included in the Status Report (See 4.9.1).

4.7.1 Achieved reliability. A plot of achieved reliability expressed as a point estimate shall be used to depict the results of the reliability growth test. This plot shall be made showing the cumulative reliability versus the cumulative test time. This plot shall not be adjusted by negating past failures because of present or future design changes. This curve shall be identified as "Achieved Reliability".

4.7.2 Adjusted reliability. A second plot shall be made to reflect the level at which the achieved reliability would be if those failures were discounted for which acceptable corrective action has resolved a failure to the satisfaction of the procuring activity. This curve shall be identified as "Adjusted Reliability".

4.7.3 Moving average. A moving average of achieved reliability is constructed by arranging the failure times (accumulated test times between failures) for the equipment on test in chronological order of occurrence. The moving average for any specific number of failures is computed as the arithmetic mean of the failure times selected sequentially and in reverse order. The number of failures to be used in the computation is arbitrary but is restricted to 10 or less. An example is shown in Appendix C. This curve shall be identified as "Moving Average" and the number of failures used for computation shall be noted.

4.8 Test program reviews. Test program reviews shall be conducted at scheduled milestones throughout the reliability development test program and shall be identified in the approved test plan. Attendance at these reviews will include procuring or user activity and contractor personnel and their designated representatives. These reviews shall be documented by the contractor and submitted as an appendix to the Status Report (See 4.9.1).

4.8.1 Test readiness reviews. A test readiness review shall be planned, scheduled, and conducted at least seven (7) days prior to the start of any test to assure that the test item and all supporting elements are ready to begin test. The test readiness review shall include, to the extent applicable, the following:

a. Status of design and fabrication,
b. Results of reliability predictions
c. Results of all applicable previous tests,
d. Summary of the open problems and failures,
e. Status of problem and failure closures,
f. Availability of test procedures approved by appropriate personnel to indicate technical review,
g. Status of previously assigned action items,
h. Assignment of action items resulting from the review, and
i. Conclusions of review (Test start approval/disapproval).

4.8.2 Status reviews. Formal reviews shall be scheduled at preplanned milestones during the reliability development test program to permit the contractor and procuring or user activity to review the status of testing. The status reviews shall be scheduled approximately monthly and shall include, to the extent applicable, the following:

a. Current reliability growth assessments and projections,
b. Results of current problem and failure investigations and engineering analyses,

c. Corrective action recommendations,
d. Potential design problems based on the corrective action recommendations,
e. Status of subcontractor and supplier reliability development tests,
f. Status of previously assigned action items, and
g. Assignment of action items resulting from the review.

4.8.3 Test completion review. A test completion review shall be scheduled at the completion of test. This review shall be conducted to evaluate the results of the testing in compliance with the requirements of the contract, equipment or model specification, and this standard. This review shall include, to the extent applicable, the following:

a. Current reliability growth assessments and achievements,
b. Status of open problems and failures,
c. Status of corrective actions,
d. Status of previously assigned action items,
e. Assignment of action items resulting from the review, and
f. Conclusions of the review.

4.9 Reports. No data shall be required by this document or the referenced documents in paragraph 2 unless specified in the contract. Reports shall be in accordance with the contract.

4.9.1 Status report. The contractor shall prepare a status report within seven (7) days from the last date of the scheduled reporting period. Each report shall present the test results and all pertinent data obtained durng the reporting period, the total number of problems and failures for each operational mode specified in the duty cycle, plots of measured and projected reliability growth assessment data, and the estimated completion date. The minutes of the test program reviews shall be included as an appendix to this report.

4.9.2 Failure summary. The contractor shall prepare a failure summary report as of the end of each month. The summary report shall be prepared in three parts: Part I, cumulative number of failures to summary date; Part II, failures for which corrective action has not been established; Part III, cumulative listing of closed reports. The contractor's existing failure summary may be used with minimum changes necessary to meet the requirements of this document.

4.9.3 Final report. A final report shall be prepared and submitted by the contractor within thirty (30) days after completion of all scheduled testing. This report shall summarize all results obtained during the reliability development test program, and shall contain copies of all test data sheets and test logs. The report shall include, but not be limited to, a comparison of results with the reliabilaity predictions, the conclusions drawn, a summary of problems and failures, the corrective actions taken, and an assessment of the reliability achieved. The final report shall define the configuration of the equipment before and after incorporation of design changes resulting from the test program.

The report shall include a tabulation of all differences between the requirements of the equipment specification and results of the test program, and provide recommendations for resolution of the noted differences. Unless otherwise specified, the final report shall also contain maintenance times for each failure or maintenance action, subdivided into the following categories, as defined in MIL-HDBK-472.

a. Localization,
b. Isolation,
c. Disassembly,
d. Interchange,
e. Reassembly,
f. Alignment,
g. Check-out, and
h. Total

4.10 Government furnished property (GFP). Equipment, facilities, and material furnished by the government will be specified in the contract. Any GFP included in the equipment to be tested will be accompanied by applicable existing reliability test data.

4.11 Inspection. Visits to the contractor's facility for assuring compliance with the reliability development test program requirements will be made by procuring or user acitivity personnel or its designated representatives.

5. DETAIL REQUIREMENTS

5.1 Test requirements. Testing of the systems and equipment shall be as specified in the equipment or model specification and the contract. The reliability development tests shall be planned in accordance with the requirements of this document to satisfy the development testing requirements of MIL-STD-785 and to provide data for the evaluation of reliability growth.

5.1.1 Test items. The test items for the reliability development tests shall be defined in the Reliability Development Test Plan. The number of items to be tested shall be as specified in the equipment or model specification.

5.1.2 Test length. The total test time (cumulative hours, cycles, rounds, etc.) for the reliability growth tests shall be as specified in the equipment or model specification. The test shall be a fixed length test based on the mission profile and the life and operational characteristics of the equipment. Unless otherwise specified, when two or more test items are used, the minimum operating time for each test item shall be not less than one-half the average operating time for all items on test.

5.1.3 Test cycle (typical). Unless otherwise specified, the test cycle shown in Figure 1 and described below, shall be used. The particular operating and storage temperatures, vibration levels, rates and frequencies of change, and equipment ON-OFF and duty cycles shall be as specified in the equipment or model specification and described in the test plan.

a. With test item OFF and vibration OFF, cool chamber to the low storage temperature and allow equipment temperature to stabilize (cold soak).

b. When test item temperature has stabilized at the low storage temperature, heat chamber to low operating temperature, turn test item ON and perform specified number of preoperational checks or run-ups.

c. Upon completing the preoperational checks, heat chamber to high operating temperature with test item ON and vibration ON and commence specified duty cycle for time specified, or if no time is specified, for two (2) hours. Unless otherwise specified, the chamber temperature shall be cycled between the upper and lower operating temperatures of the equipment during this portion of the test cycle at the specified rate and frequency of change.

d. Upon completing the duty cycle period, turn test item and vibration OFF, heat chamber to the high storage temperature, and allow test item to stabilize (hot soak).

e. When test item temperature has stabilized, cool chamber to high operating temperature, turn item ON and perform the specified number of preoperational checks or run-ups.

f. Upon completing specified number of preoperational checks, cool chamber to the low operating temperature with test item ON and vibration ON and commence specified duty cycle for the time specified, or if no time is specified, for two (2) hours. Unless otherwise specified, the chamber temperature shall be cycled between the upper and lower operating temperatures during this portion of the test cycle at the specified rate and frequency of change.

g. Upon completing the duty cycle period, turn test item and vibration OFF and repeat cycle from (a) above.

5.2 Other specified tests. The data acquired during other tests described in the equipment or model specification shall be used to monitor reliability growth. The data obtained from all testing, including component and weapons replaceable assembly (WRA) testing, shall be included in the planned failure reporting and corrective action system. Failure modes associated with system interfaces that are identified during testing shall be reported.

Preparing Activity:

Navy - AS
(Project MISC NB59)

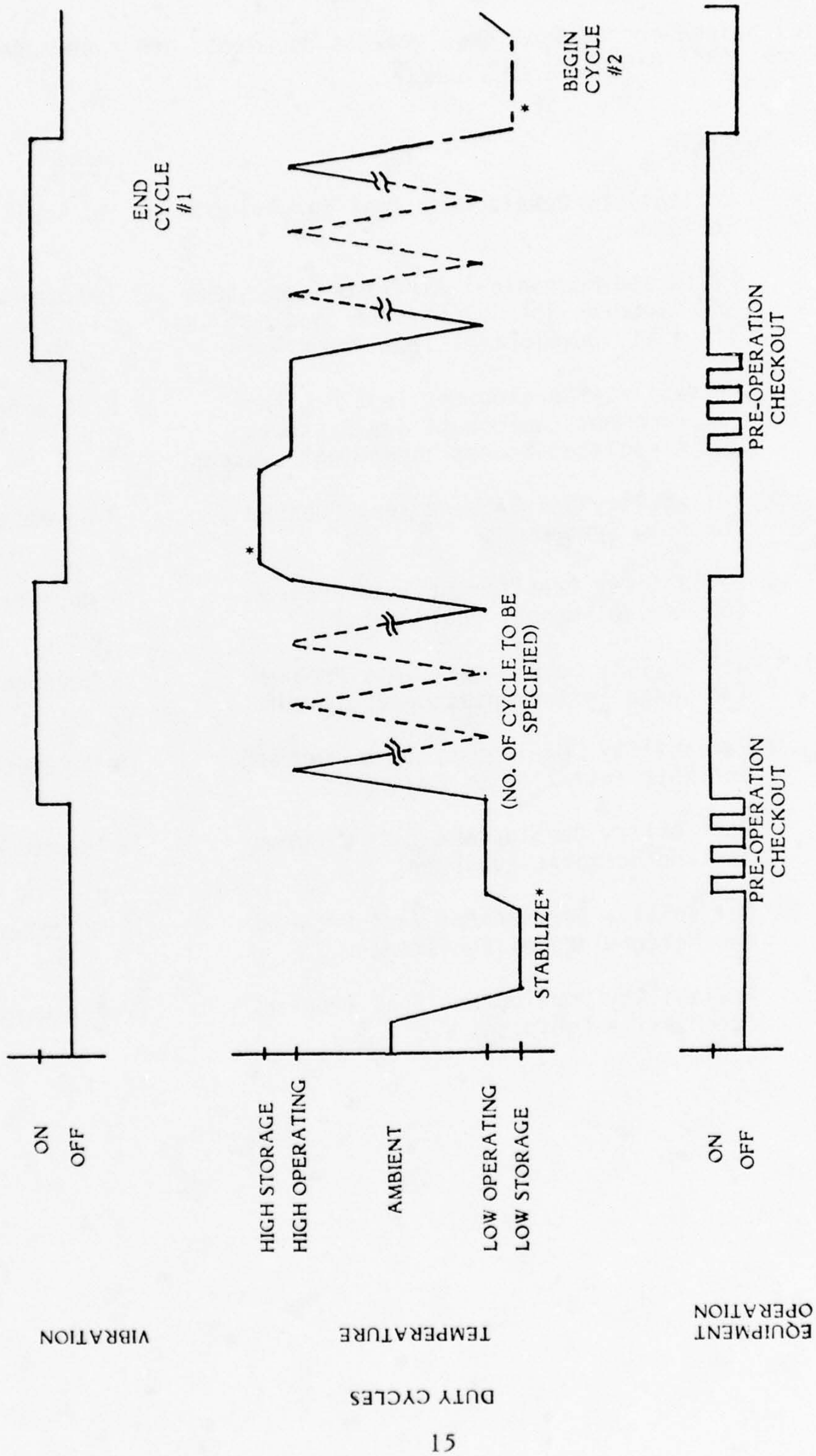

FIGURE 1 - TEST CYCLE (TYPICAL)

NOTES

Supersession Note.

The following Aeronautical Requirements documents are superseded by MIL-STD- 2068 (AS) dated 21 March 1977 .

No.	Title	Date
AR-104	Reliability Development Test for Avionic Equipment	30 April 1974
AR-108	Fluid and Mechanical Airframe Subsystems and Airborne Special Mission Systems; Reliability Development Test Program for	8 November 1974
AR-111	Reliability Development Test Program for Armament Equipment, Gun Systems, and Associated Stores Management Systems	8 November 1974
AR-112	Reliability Development Test Program for Crew Systems	8 November 1974
AR-113	Reliability Development Test Program for Ground Support Equipment	8 November 1974
AR-114	Reliability Development Test Program for Range Instrumentation Equipment	15 November 1974
AR-115	Reliability Development Test Program for Ship Installation Equipment	15 November 1974
AR-116	Reliability Development Test Program for Photographic Equipment	15 November 1974
AR-117	Reliability Development Test Program for Meteorological Equipment	15 November 1974
AR-118	Reliability Development Test Program for Missile Equipment	22 February 1976

APPENDIX A
RELIABILITY PROGRAM TASKS

10. GENERAL

10.1 Scope. This appendix describes reliability program tasks that shall be completed and approval obtained from the procuring activity prior to the start of the reliability development test program.

10.2 Application. Each task described under 50.1 is presented as a guide only. It is incumbent on all concerned to specify a reliability program in accordance with MIL-STD-785 and to require a reliability program plan for approval.

20. REFERENCED DOCUMENTS

20.1 Issues of documents. The following documents of the issue in effect on date of invitation for bids o request for proposal, form a part of this appendix to the extent specified therein.

STANDARDS
MILITARY

MIL-STD-756	Reliability Prediction

HANDBOOKS
MILITARY

MIL-HDBK-217	Reliability Prediction of Electronic Equipment

PUBLICATIONS

AD-821640	Rome Air Development Center (RADC) Reliability Notebook
RADC-TR-73-248	Dormancy and Power On-Off Cycling Effects on Electronic Equipment
RADC-TR-75-22	Non-Electronic Reliability Notebook

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

30. DEFINITIONS

30.1 Derating criteria. A standard that established the ratio of maximum applied stress to rated stress for parts applications.

40. GENERAL REQUIREMENTS

40.1 Reliability program tasks.

40.1.1 Mission profile. This task is accomplished early in the conceptual phase and is used to define the operational modes of the system.

40.1.2 Environmental profile. This task follows the mission profile definition and is used to define the worst case environments during the life of a system.

40.1.3 Reliability block diagram. This task is accomplished during initial design after the system configuration is defined.

40.1.4 Reliability mathematical model. This task follows the reliability block diagram and is prepared by a review of the block diagram. Reliability predictions are used as inputs for solution of the mathematical model.

40.1.5 Reliability predictions. This task is accomplished during design and the results are used to guide the design.

40.1.6 Reliability allocations. This task is accomplished with the reliability prediction task and is used to allocate system failure allowances among the system elements.

40.1.7 Failure mode, effects, and criticality analysis (FMECA). This task is accomplished early in the design phase and is used to identify potential failures inherent in the equipment.

40.1.8 Stress analysis. This task is accomplished during the detail design and is used to identify maximum actual stresses and to guide the design.

40.1.9 Worse case analysis. This task is accomplished during the detail design and is used to identify any detrimental output responses when parts or components are considered to be at detrimental tolerance limits.

40.1.10 Sneak circuit analysis. This task is accomplished during detail design to identify latent paths in the design that can result in undersirable responses.

50. DETAIL REQUIREMENTS

50.1 Development of reliability program tasks. The reliability program tasks must be developed early in the conceptual and development phases of a program and shall be approved by the procuring activity prior to the start of the reliability development tests.

50.1.1 Mission profile. A graphic or tabular presentation describing equipment performance requirements as a function of time and showing the occurrences of scheduled events, their sequence and duration, during a complete operational mission. The mission profile is used to define the equipment duty cycle and to determine realistic operational test levels to be applied during the reliability development test.

50.1.2 Environmental profile. A graphic or tabular presentation of the worst case environments (both natural and induced) that an equipment will be subjected to from acceptance to the end of useful life. This profile is used to determine the realistic environmental test levels to be applied during the reliability development test.

50.1.3 Reliability block diagram. A graphic analog of logical events that result in the success or failure of the hardware. The block diagram is the first step in modeling system reliability.

50.1.4 Reliability mathematical model. An algebraic analog of the block diagram that is prepared by reviewing the block diagram. The mathematical model is used to determine the reliability of the system and items hereof.

50.1.5 Reliability predictions. An analytical estimation of the numerical reliability of an equipment postulated on the analysis of realistic and conservative failure rate data. This prediction shall be done in accordance with the design prediction procedure of MIL-STD-756 for each distinct mission phase or mode of operation. The prediction shall be based on failure rate data from sources such as MIL-HDBK-217, RADC Reliability notebook, RADC-TR-73-248, and RADC-TR-75-22. Other realistic and conservative failure rate data sources, including contractor in-house data, can be used but requires prior approval of the procuring activity. The prediction report shall be approved by the procuring activity prior to the start of testing.

50.1.6 Reliability allocation. The numerical reliability requirement for the equipment shall be subdivided and allocated to each item within the equipment. The rationale supporting the allocations shall be approved by the procuring activity.

50.1.7 Failure mode, effects, and criticality analysis (FMECA). A systematic procedure for examining and classifying all the ways in which a system may fail, together with the effects of the failure modes on the system and their consequences to performance of the mission. The FMECA should be carried down to the component and circuit level where the effects of individual part failures can be studied.

50.1.8 Stress analysis. An analysis conducted to identify the maximum actual stresses (e.g., thermal, electrical, mechanical) induced on a part in its application. The results of this analysis are compared with the parts derating criteria to determine overstress conditions.

50.1.9 Worst case analysis. An analysis conducted to determine that a design will give proper response for all allowable inputs with all components considered to be at the most detrimental initial or end of life tolerance limits for all specified environmental conditions.

50.1.10 Sneak circuit analysis. An analysis conducted to determine any latent path in a design which may result in an undersirable response to an allowed input under planned operating conditions.

50.2 Other reliability design techniques. The use of redundance, stress-strength analysis, and other reliability oriented design techniques shall be used in designing equipment to enhance equipment reliability.

APPENDIX B
FAILURE CLASSIFICATION FOR RELIABILITY GROWTH ASSESSMENT

10. GENERAL

10.1 Scope. This appendix establishes criteria for classification of failure occurring during the reliability development tests.

10.2 Application. The ground rules and scoring criteria included in this appendix shall be used to classify failures as either relevant or nonrelevant for the purpose of assessing reliability growth of the equipment.

20. REFERENCED DOCUMENTS

Not Applicable.

30. DEFINITIONS

30.1 Failures. In addition to the definition of failure as given in MIL-STD-721, and any definition given in the applicable reliability test specification and this standard, the following criteria for the determination of a failure shall apply:

Whenever any of the performance characteristics are outside of the requirements of the equipment or model specification at any specified environmental conditions, at least one failure has occurred.

40. GENERAL REQUIREMENTS

40.1 Failure reporting. All problems and failures and the conditions under which they occurred shall be reported and investigated in accordance with the requirements of this standard.

40.2 Failure classification. All failures occurring during reliability development tests, including failures occurring during equipment burn-in under the environmental conditions specified for the reliability development test, shall be classified and reported as either relevant or nonrelevant. Only those failures occurring during the reliability development tests and classified relevant shall be used in computing equipment mean time between failure (MTBF) and for making reliability growth assessments.

40.3 Relevant failures. All failures are relevant unless determined by the procuring or user activity, or an authorized representative thereof, to be caused by a condition external to the equipment under test which is not a test requirement.

40.3.1 Design failures. Failures due to design deficiencies of either the equipment or component parts shall be classified relevant.

40.3.2 Workmanship failures. Failures resulting from workmanship or quality control shall be classified as relevant.

40.3.3 Component part failures. Failures due to defective component parts shall be classified as relevant failures. Each independent failure of component parts of the same type shall be considered a separate relevant failure.

40.3.4 Wearout parts. Certain parts of known limited life, such as batteries, may have a life stipulated prior to the initiation of testing as approved by the procuring activity. Failures of these parts occurring prior to the end of the stipulated period are relevant. Failures of these parts occurring after the stipulated period are nonrelevant, but any dependent failures caused thereby are relevant.

40.3.5 Multiple failures. In the event simultaneous part failures occur, each failed part which would independently prevent satisfactory equipment performance shall be counted as a relevant failure.

40.3.6 Intermittent operation. The second and subsequent occurrences of an intermittent operation on any one item under test shall be counted as a relevant failure. (See 40.4.5).

40.3.7 Adjustments. Each adjustment of a control which could not readily be accomplished during a mission shall be classified as a relevant failure.

40.3.8 Built-in test failures. A failure of the built-in test (BIT) functions that degrades sytem performance beyond the acceptable limits shall be classified relevant. False alarms of BIT functions shall be classified as relevant failures.

40.3.9 Other failures. All other failures not specifically defined as nonrelevant shall be classified as relevant.

40.4 Nonrelevant failures. Although nonrelevant failures are not used for MTBF calculations or for reliability growth assessments, all failures shall be recorded and investigated.

40.4.1 Improper test installation. Failures directly attributable to improper installation in the test facility shall be classified nonrelevant.

40.4.2 Test instrumentation failures. Failures directly attributable to a failure of the test instrumentation or monitoring equipment, except BIT, shall be classified nonrelevant.

40.4.3 Test operator errors. Failures resulting from test operator error in setting up or in testing the equipment shall be classified nonrelevant.

40.4.4 Test procedure errors. Failures resulting from an error in the test procedures shall be classified nonrelevant.

40.4.5 Intermittent operation. The first occurrence of an intermittent operation on any one item under test shall be classified as nonrelevant. (See 40.3.6).

40.4.6 Repair failures. Failures that result from trouble-shooting, repair verification or scheduled maintenance shall be classified nonrelevant if the failure occurs during repair and verification as described in the test plan.

50. DETAIL REQUIREMENTS
Not applicable.

APPENDIX C

EXPLANATORY INFORMATION

10. GENERAL

10.1 Scope. This appendix contains explanatory information.

10.2 Application. The information in this appendix is for the guidance of the procuring activity and does not contain direct requirements of this standard.

20. REFERENCED DOCUMENTS
Not applicable.

30. DEFINITIONS
Not applicable.

40. GENERAL

40.1 Data requirements. Data items generated in accordance with this standard are not deliverable unless specified on the Contract Data Requirements List (DD Form 1423) or the contract schedule. This standard applies to, but is not restricted to, the following Data Item Descriptions (DD Form 1664).

a. UDI-T-22723 Thermal Survey Report
b. UDI-R-21134 Report, Reliability and Maintainability Prediction
c. UDI-R-21140 Report, Analysis, Failure Modes and Effects
d. UDI-R-21135 Plan, Reliability Test
e. UDI-R-21139 Report, Failure Summary
f. UDI-R-21136 Report, Reliability Test Results

40.2 Moving average example. Table I is an example of the computation of moving average utilizing 1, 2, 3, ... 6 failures in the computation. The moving average is constructed by arranging the failure times (accumulated test time between failures) for the items on test in chronological order of occurrence. The moving average for any given number of failures is computed as the arithmetic mean of that number of failure times selected sequentially and in reverse order. For example, the moving average of two failures is obtained by adding the last two failure times and dividing by two; for three failures, by summing the last three failure times and dividing by three; etc. The number of failures used in the computation is arbitrary but should be restricted to ten or less. Initially, some moving averages cannot be computed since enough failures have not occurred. For example, the moving average utilizing the last six times between failures cannot be computed until six failures have occurred. The failure times were selected arbitrarily for this example. The times between failures are arranged in chronological order and indexed by the cumulative failure count. The cumulative test time is the total of all time between failures up to and including the failure time indexed.

TABLE I
MOVING AVERAGE

Cum. Fail. Count	Cum. Test. Time	Time Between Fail.	Cum. MTBF	Moving MTBF Using Last (N) Failures (N is Table Index) 1	2	3	4	5	6
1	1	1	1	1	0	0	0	0	0
2	4	3	2	3	2	0	0	0	0
3	8	4	3	4	4	3	0	0	0
4	13	5	3	5	5	4	3	0	0
5	20	7	4	7	6	5	5	4	0
6	30	10	5	10	9	7	7	6	5
7	42	12	6	12	11	10	9	8	7
8	57	15	7	15	14	12	11	10	9
9	78	21	9	21	18	16	15	13	12
10	104	26	10	26	24	21	19	17	15
11	136	32	12	32	29	26	24	21	19
12	177	41	15	41	37	33	30	27	25
13	228	51	18	51	46	41	38	34	31
14	292	64	21	64	58	52	47	43	39
15	372	80	25	80	72	65	59	54	49
16	473	101	30	101	91	82	74	67	62
17	599	126	35	126	114	102	93	84	77
18	757	158	42	158	142	128	116	106	97
19	956	199	50	199	179	161	146	133	121
20	1205	249	60	249	224	202	183	167	152
21	1518	313	72	313	281	254	230	209	191
22	1879	361	85	361	337	308	281	256	234
23	2262	383	98	383	372	352	327	301	277
24	2668	406	111	406	395	383	366	342	319
25	3099	431	124	431	419	407	395	379	357

40.3 Test time. One of the main purposes of the reliability development test is to design out failure causes. This process will necessarily involve time to detect and analyze failures as well as redesign and, for test purposes, fabricate hardware. Thus, for slow occurrences of failures in test the critical variable is test time while, if the redesign and resulting hardware change takes considerable time, then calendar time becomes the significant variable. The test duration must be specified in the equipment or model specification and should be based on an analysis of the mission profile, operational and life characteristic of the item, and the program requirements, (e.g., budget, schedule, resources, etc.). The reliability development test should be planned as a fixed length test and the test duration must be specified. Fixed length test times of 10 to 25 multiples of the specified MTBF will generally provide a test length sufficient to achieve sufficient to achieve the desired reliability growth for equipment in the 50 to 2000 hours range. For equipments over 2000 hours, test

lengths should be based on equipment complexity and the needs of the program, but as a minimum, should be one multiple of the specified MTBF. In any event, the test length should not be less than 2000 hours or more than 10,000 hours.

40.4 Corrective action. Corrective action shall have been developed for all failures experienced in the Reliability Development Tests and such corrective action shall have been incorporated in the equipment to be subjected to the Reliability Demonstration required by MIL-STD-785. In aircraft and missile programs, no flight testing shall be performed until after the Reliability Development Tests have been completed and no aircraft or missiles shall be delivered to operating units until corrective action for all failures experienced during the Reliability Development Tests have been incorporated.

40.5 Specification requirements. Equipment or model specifications shall contain the following:

a. Test levels (see 4.3).

b. Temperature (see 4.3.1).

c. Vibration (see 4.3.2).

d. On-off cycling (see 4.3.3.1).

e. Duty cycle (see 4.3.3.2).

f. Performance parameters (see 4.5).

g. Performance measurements (see 4.5.3).

h. Test requirements (see 5.1).

j. Test length (see 5.1.2).

k. Test cycle (see 5.1.3).

50. DETAIL REQUIREMENTS
Not applicable

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL	OMB Approval No. 22-R255

INSTRUCTIONS: The purpose of this form is to solicit beneficial comments which will help achieve procurement of suitable products at reasonable cost and minimum delay, or will otherwise enhance use of the document. DoD contractors, government activities, or manufacturers/vendors who are prospective suppliers of the product are invited to submit comments to the government. Fold on lines on reverse side, staple in corner, and send to preparing activity. Comments submitted on this form do not constitute or imply authorization to waive any portion of the referenced document(s) or to amend contractual requirements. Attach any pertinent data which may be of use in improving this document. If there are additional papers, attach to form and place both in an envelope addressed to preparing activity.

DOCUMENT IDENTIFIER AND TITLE
MIL-STD-2068(AS) RELIABILITY DEVELOPMENT TESTS

NAME OF ORGANIZATION AND ADDRESS

CONTRACT NUMBER

MATERIAL PROCURED UNDER A

☐ DIRECT GOVERNMENT CONTRACT ☐ SUBCONTRACT

1. HAS ANY PART OF THE DOCUMENT CREATED PROBLEMS OR REQUIRED INTERPRETATION IN PROCUREMENT USE?

A. GIVE PARAGRAPH NUMBER AND WORDING.

B. RECOMMENDATIONS FOR CORRECTING THE DEFICIENCIES

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APPENDIX E

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE

RESEARCH IN TESTING AND EVALUATION METHODOLOGY

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE
Northridge, California 91324
"IN THE SAN FERNANDO VALLEY"

SCHOOL OF ENGINEERING
AND COMPUTER SCIENCE
(213) 885-2183

RESEARCH IN TESTING AND EVALUATION METHODOLOGY

Testing and Evaluation (T&E) is an engineering activity of major economic importance to which little or no attention has been given in engineering academic programs or research. A number of corporations and government agencies have carried on extensive T&E functions for some time. Recent changes in laws concerning government purchasing and consumer product liability will undoubtedly extend the interest in such activities. Accordingly, there will be an increasing demand for attention to T&E by the engineering profession and their academic community.

During the past four years, the School of Engineering and Computer Science at California State University, Northridge, has undertaken several activities associated with T&E. The School has been involved with the U. S. Navy Pacific Missile Test Center at Pt. Mugu, California in developing a graduate engineering program with emphasis in Testing and Evaluation. Although this program leans heavily toward the specific interests of the U. S. Navy and much of the background material is derived from military and other government agency experience with T&E, there appears to be significant interest among engineers working within the civilian economic sector center for a similar program if it were not so heavily oriented toward the military. Furthermore, if T&E is such a

significant engineering activity as preliminary analysis would indicate, some attention should be given to its normal inclusion in engineering curricula. For example, Testing and Evaluation would appear to be an integral part of the design process, although it is invariably neglected in teaching design. However, to pursue further the development of T&E within engineering academia, a thorough study of Testing and Evaluation as practiced throughout industry, especially in the civilian sector, must be undertaken.

During the 1975-1976 academic year, a research program on the California State University, Northridge campus did investigate and analyze T&E practices within the U. S. Navy, resulting in a series of monographs ordering portions of Naval philosophy and practice. As part of that study, major U. S. corporations were surveyed to assess their interest and involvement with T&E. A copy of those survey results are attached. The responses did indicate a keen interest and extensive involvement, though practices probably varied widely between different organizations. Undoubtedly there is an extensive methodology of T&E employed throughout industry and government, but it does not appear to be collected and available through any single source. This is particularly evident if one is concerned with conceptual advances and managerial philosophy in Testing and Evaluation as opposed to specific results of a test of a particular piece of hardware.

The School of Engineering and Computer Science has also sponsored two seminars in an effort to encourage formal dialogues in Testing and Evaluation. The first of these seminars initiated an effort to perceive the T&E needs of the public and private sectors and to provide representatives of those sectors with information regarding the role that academic institutions might play in the development of T&E as a recognized discipline. Papers au-

thored by members of the T&E community were presented at the second seminar. Additionally, faculty at the School have instituted informal dialogues with several members of the T&E community.

At this point, we would propose mounting a research effort in the methodology of Testing and Evaluation. Such a study should include at least:

1. Extensive search for all literature pertinent to T&E and the compilation of a T&E data bank or bibliography.

2. An extensive examination of T&E methodologies throughout industry and government, including on-site visits to a variety of organizations and industries to determine the what, how, and why of their T&E programs.

3. A functional analysis of the collected information to define any definite patterns or commonality; i.e., to organize the material into a consistent body of knowledge.

4. An analysis of the information to determine what special areas of knowledge or skills are needed in T&E practice, and which of those should be incorporated into engineering curriculum.

5. A recommendation for Testing and Evaluation curricula as part of undergraduate and graduate engineering programs.

We think such a project could be completed successfully and that the results would be beneficial to the engineering profession, education, and industry. Within the School of Engineering and Computer Science at California State University, Northridge, we have more experience in this field than will be found at any other academic institution. Furthermore, from our experience in T&E, we have developed contacts with many of the current practitioners who are interested and willing to help. All that remains is to obtain adequate funding to undertake such an extensive effort.

January, 1977

CALIFORNIA STATE UNIVERSITY, NORTHRIDGE
Northridge, California 91324
"IN THE SAN FERNANDO VALLEY"

SCHOOL OF ENGINEERING
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June, 1976

Dear Sir:

We wish to share with you some preliminary results of a survey of U.S. industry regarding the field of Testing and Evaluation that we conducted in the latter part of 1975 and continued into the early part of this year. We find these preliminary results most illuminating. The field of Testing and Evaluation is definitely becoming increasingly important in major U.S. firms.

As a result of the survey responses, we held a one-day seminar for local industry executives in January and were able to further determine the needs of the Testing and Evaluation community. These and other research activities have evolved into a short course on Testing and Evaluation to be offered in July of this year. A brochure is enclosed and we hope that you will join us.

Yours truly,

Charles F. Sanders, Dean

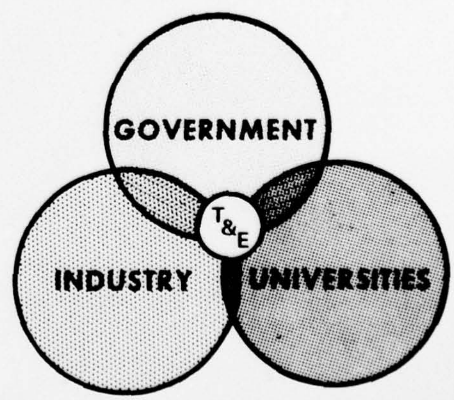
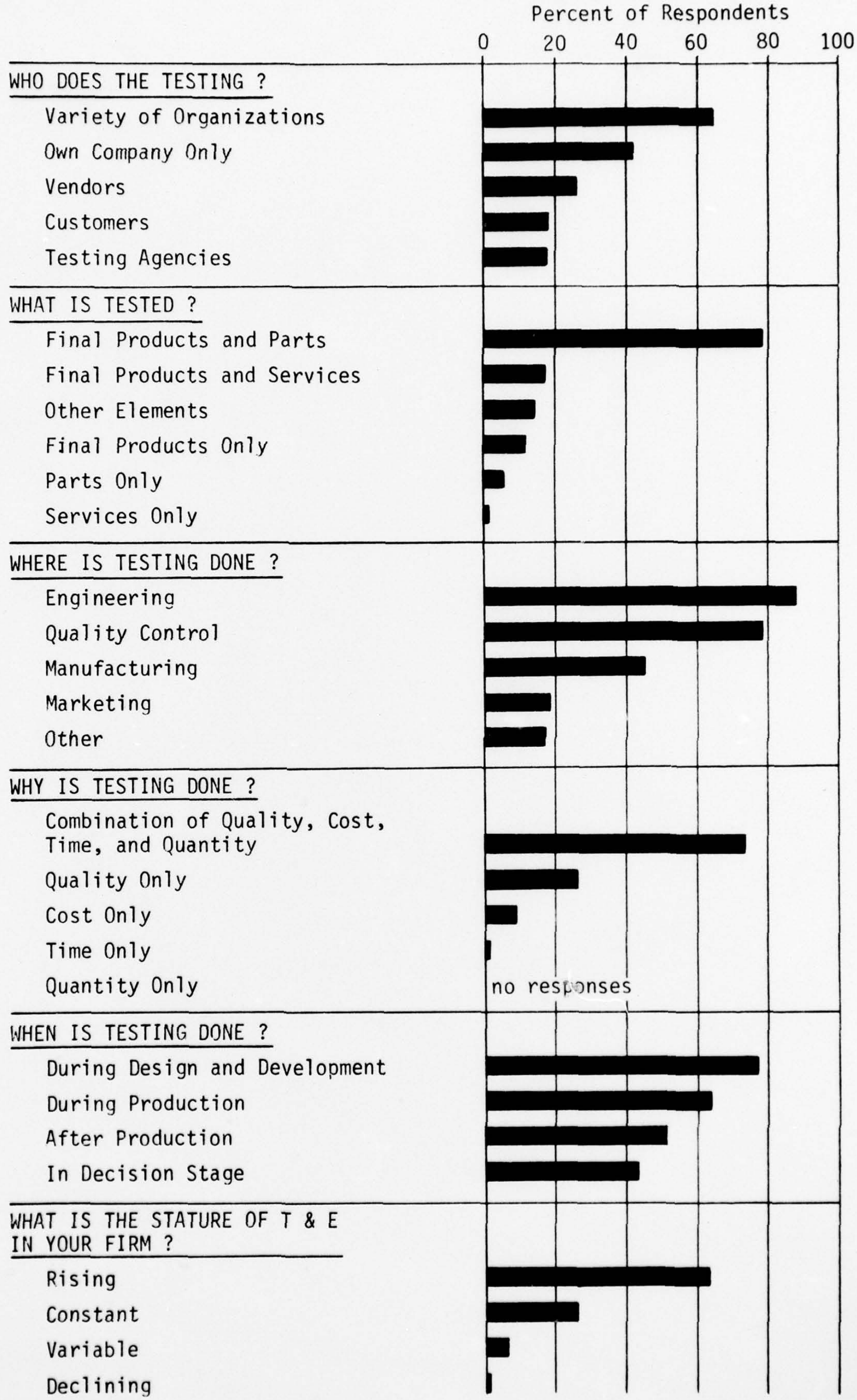


EXHIBIT I GENERAL INFORMATION



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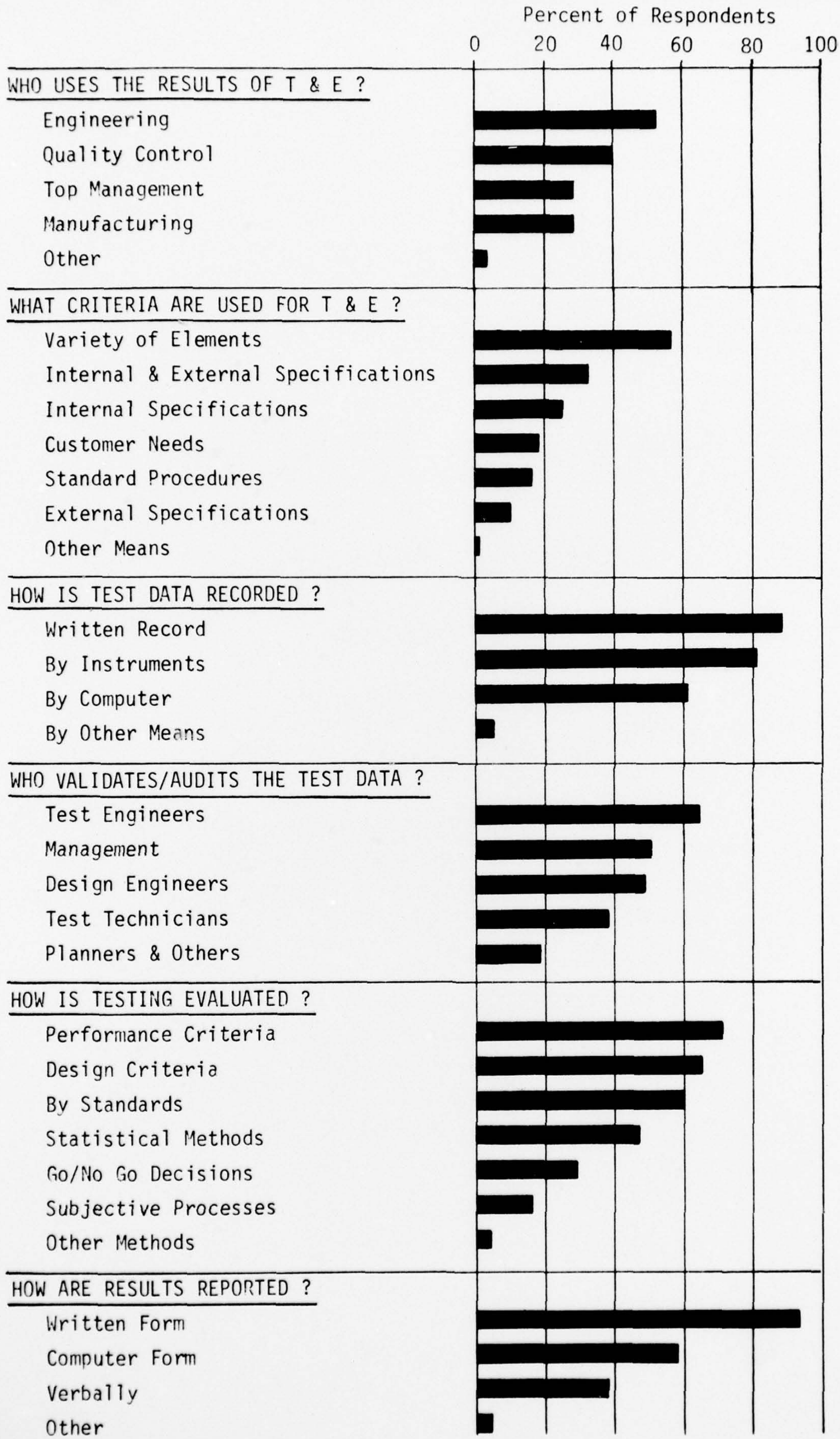
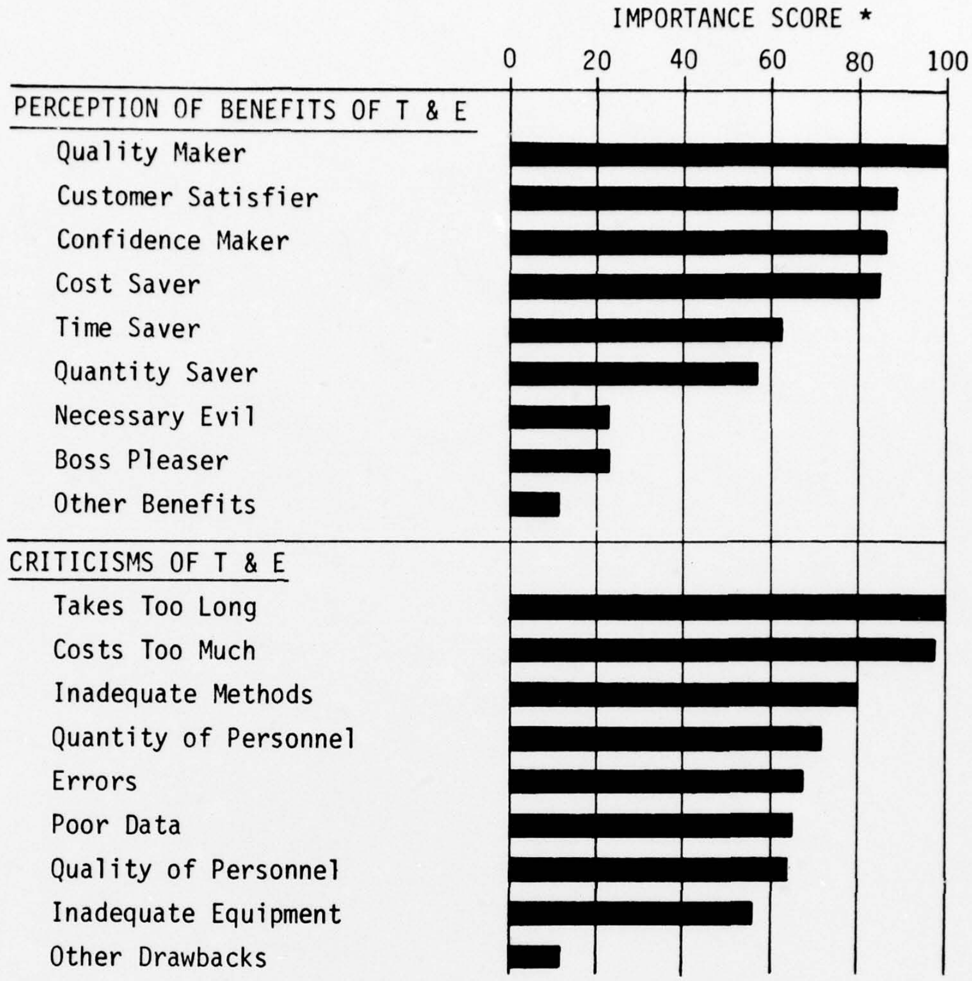


EXHIBIT II

TEST AND EVALUATION PROCESSES

EXHIBIT III

ATTITUDES TOWARD T & E



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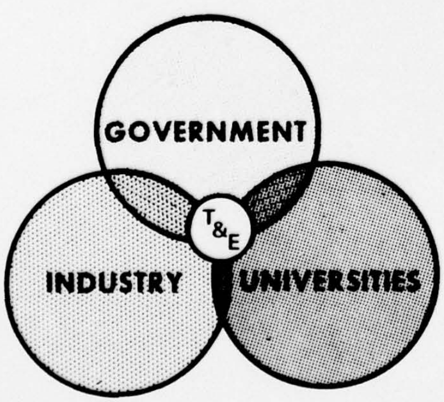

FOR FURTHER INFORMATION REGARDING THIS AND OTHER RESEARCH IN THE FIELD OF TESTING AND EVALUATION, CONTACT

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